VOLUME LVI SEPTEMBER, 1946 NUMBER 9

THE LARYNGOSCOPE

FOUNDED IN 1896

BY

MAX A. GOLDSTEIN, M. D.

PUBLISHED BY

THE LARYNGOSCOPE

640 SOUTH KINGSHIGHWAY ST. LOUIS (10), MO., U. S. A.

NOTICE TO CONTRIBUTORS

THE LARYNGOSCOPE reserves the right of exclusive publication of all articles submitted. This does not preclude their publication in Transactions of the various Societies.

Manuscripts should be typewritten, double spaced, on one side of paper only and with sufficient margins to allow for corrections.

References should be complete: author's surname, initials, title of article, journal, volume, page, month, year.

Six illustrations will be furnished for each article without cost to author. Authors will please limit illustrations to six or assume the expense of additional illustrations.

Proofs will be submitted to authors for corrections. If these are not returned, articles will be published as corrected in this office.

Reprints will be furnished at the following prices:

WITHOUT COVER

	250 Copies	500 Copies	1000 Copies	2000 Copies
Four Pages	$ 7.25	$ 8.75	$11.75	$17.50
Eight Pages	15.00	19.00	25.50	38.00
Twelve Pages	22.50	28.50	40.50	64.50
Sixteen Pages	29.00	35.50	47.50	70.00
Twenty Pages	35.00	43.00	59.00	88.00
Twenty-four Pages	42.50	51.50	69.50	104.50
Thirty-two Pages	55.00	66.00	88.00	129.00

WITH COVER

Four Pages	$13.25	$17.00	$24.50	$39.00
Eight Pages	21.00	27.25	38.25	59.50
Twelve Pages	28.50	36.75	53.25	86.00
Sixteen Pages	35.00	43.75	60.25	91.50
Twenty Pages	41.00	51.25	71.75	109.50
Twenty-four Pages	48.50	59.75	82.25	126.00
Thirty-two Pages	61.00	74.25	110.75	150.50

Express charges to be paid by consignee.

THE
LARYNGOSCOPE.

VOL. LVI SEPTEMBER, 1946. No. 9

PRESIDENTIAL ADDRESS.*

GORDON BERRY, M.D.,

Worcester, Mass.

As tradition directs, I am opening the Seventy-eighth Annual Meeting of the American Otological Society with a formal report. For each successive president whom you have elevated to this position of honor and dignity this becomes the peak of his otological career. For some there are yet other peaks to scale. The present incumbent while enjoying mountain climbing also recalls a certain Humpty-Dumpty who sat high on a wall. Like so many others in high places, he made a mistake, and his descent was uncomfortably rapid. The Scotch Bard explains the hazard:

> Oh wad some power the giftie gi'e us
> To see oursel's as ithers see us!
> It wad frae monie a blunder free us,
> And foolish notion.

The exigencies of war have complicated the last two presidential terms. Dr. Bowers and then I have each prepared for a regular annual meeting and then been obliged to cancel it and carry over to a second year. During these four years, Canada and the United States have fought and suffered together through the most devastating war in all history. We have won the war, but now after a year of earnest effort we are, oh so far from winning the peace. Human relations are greatly disturbed; labor and management are at each other's throats, while industry halts and people starve; national and

*Read at the Seventy-eighth Annual Meeting of the American Otological Society, Inc., Chicago, Ill., May 31, 1946.

Editor's Note: This ms. received in Laryngoscope Office and accepted for publication, July 23, 1946.

individual morals and ideals are at a low ebb; selfishness prevails in both high and low places.

> Years hence, perhaps may dawn an age,
> More fortunate, alas! than we,
> Which without hardness will be sage,
> And gay without frivolity.

Medicine shares in this confusion. Perhaps far too long, we have been content with the skilled-craftsman rôle and have failed to realize that modern efficiency demands a more universal application of the healing art than our individualistic and haphazard methods can realize. We are glad that our skill is needed, but we would like to apply it as our fathers did. Wise leaders among us are struggling toward a solution. . . . We are anxious in this uncertain future.

Otology has its own problem. The advances in endocrines, blood chemistry, histamine balance, chemotherapy and penicillin administration have had their impact on ear surgery. Some claim we are passing through a cycle of less serious ear diseases. Certainly the mastoid and brain infections of two decades ago are much diminished. Our hospital internes and residents see hardly enough major surgery to fit them for our specialty. Adenotonsillectomies and submucous resections require skill and help meet the taxes, but they are scarcely challenging. . . . The future seems uncertain. Otology shares in this worldwide confusion.

Is this a true picture? Or may we find some of the confusion to be in our thinking? Could we by clearer analysis and a courageous out-reaching, even into untried fields, re-establish our faith in our destiny and our confidence in the essential verities? Let us turn the tapestry and look at the brighter side!

The stimulating program we are about to hear may give us a clue. As otologists we strive first to protect against the hazards of infection and second to prevent or alleviate the handicap of deafness. First, then, we may investigate even more zealously and apply with yet greater diligence the increasing number of agencies that control infections, and thus throttle these dreaded diseases before they require sur-

gery. This is an intriguing field to challenge the best of our enthusiasts.

Second, when deafness has won its way, shall we entrust the testing and fitting of hearing aids entirely to the commercial agent, or shall we earnestly and intelligently apply our otological knowledge to this so important field? Without question, a great number of people will seek and secure hearing aids. We would seem negligent if we fail to acquaint ourselves with these therapeutic and curative agents. Especially would I urge our younger men to delve into the mysteries of electricity and acoustics, the better to serve those seeking this help. . . . This afternoon we will learn for the first time from the extensive researches on hearing aids made by the government during the war. Then we may listen to how the testing has been developed by experienced experts, in the Army, in the Navy and in England.

Are we taking an intelligent and forward-looking stand against the noise menace? We know full well that many of our patients are injuring their hearing with acoustic trauma. Do we shrug our multiple shoulders and shed the responsibility off onto industry? Have we the courage to estimate disabilities that arise, offer solutions, acquaint the public with the hazard and seek a practical remedy? The Symposium on Noise will deal with this ever present problem.

Some of our skilled surgeons have courageously undertaken the fenestration operation. Are we seeking an honest evaluation? If the operation can be made successful and foolproof, it will deserve our ardent support for selected cases. Some of our members are devoting much thought to the problem. . . We are asking for reports from these critical studies.

Other constructive efforts deal with hydrops of the labyrinth and with facial nerve pathology. These are refined surgical procedures worthy of the best skill we can muster.

What of the hereditary aspects of deafness? Have we gone into this field as adequately as we might? The otologist has a direct interest. . . . I am looking forward to hearing from the elaborate researches at the Clarke School for the Deaf, and of the conclusions that may be drawn therefrom.

I have dwelt on these details, partly to advise you of the carefully prepared papers we are soon to hear, and partly to point out that there are many unexplored fields to enter and know in the art of otology, sufficient to challenge our best endeavor. . . . We find, then, that the picture has a bright side. We as otologists have reason to be optimistic and of good courage. Also, we are very grateful to those who will so generously enlighten us on the special investigations they have been carrying forward.

During the two years that have passed since last we met, the Grim Reaper has taken his toll. At the proper time our secretary will present memorials to those who have passed away. In my official capacity it is fitting that I make especial note of the loss of two of your officers. Dr. Charles T. Porter was a greatly valued member of the Council at his untimely death. To fill his place the Council requested Dr. Seydell to come back into harness. He graciously complied, and our deliberations have been enriched by his experience and wisdom. . . . Dr. Isidore Friesner was our well beloved secretary when he left us suddenly on Sept. 8, 1945. We have missed him sorely. For many years this Society relied on Dr. Harris, and then on Dr. Friesner, for handling the many essential details. Your president tried to carry on in such manner as Dr. Friesner would approve, until Dr. Hoople our efficient new secretary, was appointed *pro tempore* on Oct. 22. I express here our sincere gratitude to Mrs. Friesner and to Miss Lucy McCuen, Dr. Friesner's loyal secretary, for their so essential help in this time of need. Two ex-presidents have passed away during these two years — Dr. Babbitt and Dr. Newhart — who served us so loyally and whom we so admired and loved. For these and other departed colleagues, we can fittingly say

> Truly he who here
> Hath run his bright career
> And served men nobly, and acceptance found,
> And borne to light and right his witness high,
> What could be better wish than then to die,
> And wait the issue.

So much for the recent past and the present. . . . Has your president any suggestions for the immediate future that may

redound to the good of our Society? Each officer's tenure is short; the Council meetings are few and far between; there is little time or chance for creative leadership. Perhaps our Society progresses more serenely without such spasmodic prodding, but I would feign present these comments; they concern four types of activities.

First, are we individually contributing our share to the annual scientific program? Ours is a small and select body. Each owes it to himself and to his Society to seek out something he can develop for the advancement of otology, and then to offer it as his humble tribute. Thus will we all profit, and otological literature be the richer. Also, the task of the Program Committee will be easier.

Second, I would refer to the many societies concerned with our field of endeavor, and the considerable effort their combined activities entail. A large proportion of our membership belongs to five national and several local specialized groups, and the Broncho-Esophageal makes yet another. This in addition to our state, district and hospital contacts and obligations. There are too many. On more than one occasion, I, as well as you, have attended the Council meetings of two and three national societies in the same winter, at different times and in separate places. Is this good planning? Adjustments are now being made in our several constitutions which will permit the Councils to have their winter meetings follow each other at the same time and place. This will help. Also, we have italicized the custom that the American Laryngological Association share the same place and adjoining dates with the American Otological Society, alternating as to priority. We have invited the American Laryngological, Rhinological and Otological Society to meet in the same week. This year the Broncho-Esophageal shares one day with us; thus are we striving toward efficiency. Whether any further simplification is wise, the future will decide. Speaking as an individual member, I would welcome a loose but definite alliance between our two senior otological and laryngological societies, patterned a little after the smoothly working assembly now obtaining between the two more diver-

gent Eye and Ear groups in the American Academy. This would add strength and dignity to a single senior society and permit a free development of the differing aims in the two allied groups.

Third, your Council has concerned itself with the relationship between the parent American Otological Society and its research program as embodied in the Central Bureau of Research, which has so long and so ably carried forward the important studies on otosclerosis. The records on certain essential relationships appear to be uncertain. To adjust these relationships and to clarify these issues, the Trustees of the Central Bureau and the Council have sought expert legal advice, and will present to you their recommendations.

Fourth, our Constitution and By-Laws have needed changing. A committee has labored earnestly and constructively to streamline the rules under which we operate. The changing of the Winter Council Meeting has been mentioned. Another recommendation asks for a new office embodying the duties of editor, librarian, historian and necrologist. One of his first duties will be to assemble a complete official file of our *Transactions*. At the moment, we can only go back 20 years. We bespeak the cooperation of the Fellows in assembling these older missing copies.

I close with a word for the more distant future. The Council has been vary careful in selecting the new candidates for you to act upon tomorrow. There are other choice men now ready for consideration next year. These and the more recently admitted members are the leaders of the future. We expect much of them. The emphasis of their thinking and research may be along somewhat different lines, but this is healthful. Change and growth are essential to the best fulfillment. The older members have carried the banner as faithfully and as valiantly as their vision and strength would permit. We have gone far under their guidance. These younger men will scale to greater heights and into hidden fields. So with assurance, together we look forward to the years ahead, when this honored Society will continue to lead in high service to Otology.

36 West Pleasant Street.

STIFFNESS LESIONS OF THE CONDUCTING MECHANISM.*†

H. B. PERLMAN, M.D.,

Chicago, Ill.

Lesions of the conduction apparatus can be described anatomically or functionally. The middle ear is an acoustic system, and lesions of this part of the peripheral ear should be described in terms of acoustic physics; however, our present knowledge of this acoustic system or technique for measuring its characteristics in the clinic is not adequate, and furthermore, clinical lesions affecting the middle ear usually influence several different acoustic factors at the same time. Experimental lesions acting in a more restricted way help us to understand better such physical properties of the middle ear as stiffness and mass. Detailed clinical studies of normal and reversible pathological states of the stiffness factor of the conducting mechanism have been described about 10 years ago by Van Dishoeck.[1]

Griesman[2] used a similar apparatus in 1921, which he called an "otosklerometer," to study conduction deafness including stapes ankylosis. He noted that a threshold sound could be made to disappear by applying a little positive pressure against the drum in a normal ear, but that in otosclerosis this did not occur. He states that negative pressure on the other hand, did not affect the loudness of the sound in a normal ear. He measured the amount of positive pressure needed to make a threshold sound disappear, and this was considered an index of the mobility of the drum and ossicular chain. The greater the degree of deafness the more positive pressure was needed to obliterate the threshold sound. He did not describe his findings any further.

About the same time, Pohlman and Kranz[3,4] reported their

*This work was aided by a grant from the Douglas Smith Foundation for Medical Research of the University of Chicago.

†From the Division of Otolaryngology of the University of Chicago.

Editor's Note: This ms. received in Laryngoscope Office and accepted for publication, June 24, 1946.

observations on auditory function with changes of pressure in the external canal and in one case found that a negative pressure of 10 cm. of water seemed to enhance the transmission of sound through the middle ear. They suggested that a constant negative pressure in the middle ear could be due to inadequate tubal function. They further suggested that in chronic tubal obstruction, variations in the hearing with changes of weather might be due to matching the barometric pressure on both sides of the drum. In a later paper they reported their observations on bone conduction with pressure changes in the external canal. In 1932, Bekesy[5] reported on his observations about bone conduction with changes of pressure in the external canal — using specially devised apparatus.

While Van Dishoeck was primarily interested in using the apparatus in evaluating Eustachian tube function, he has published several papers since that time describing his method and observations in various conditions of the conducting mechanism. Few corroborating clinical studies have appeared. It seems indicated to review these observations, to describe the method and to report general impressions obtained by using this method over a three-year period in a large variety of middle ear and Eustachian tube diseases.

In 1937, Van Dishoeck described a simple method for measuring the pressure of the air in the middle ear of patients in the clinic. This method was based on an airtight sound source delivered through tubing to the patient's ear. Connected with this system was a hand bulb used for making small static pressure changes and a water manometer to record these pressures. The patient kept the ear tip at the end of the tube firmly in his external canal so that his ear completed an airtight system with the sound source. Any handmade change in the static pressure within this system would extend to the surface of the drum and would thus alter the function of the conduction apparatus. If the subject were listening to a sound of constant intensity he would note alterations in its loudness when static pressure changes were created over the external surface of the drum. The sound source was made to function uniformly in the face of this static pressure change by perforating the vibrating diaphragm of

the telephone earpiece used as the sound source in the apparatus. A small change in air density in itself does not alter appreciably the intensity of the propagated sound. The changes in loudness were the direct result of alteration in the function of the patient's conducting mechanism. Possible effects of this static pressure on the function of the inner ear were considered, but no alteration of function is likely even if a pressure change could be maintained within the labyrinth by this means. The static pressure delivered to the labyrinth could not be maintained but would be dissipated intracranially and through the round window. The alteration in pressure needed to obtain maximum loudness of the sound was taken as an index of the difference of air pressure between the middle and external ear. If no difference existed, then maximum loudness was experienced at or very nearly at zero pressure. In other words, no alteration of external pressure was required to match the middle ear pressure. As was to be expected, a static pressure of plus or minus 1 or 2 cm. of water resulted in reduction of loudness in a normal subject. If the Eustachian tube failed to ventilate the middle ear, Van Dishoeck considered that a reduction of the air pressure in the middle ear would result and that this reduction could be detected with the pneumophone. A reduction from normal atmospheric pressure up to 50 cm. of water was found in pathological middle ears by this method. Subsequent examination by Van Dishoeck[6,7,8] of a larger series of normal adults indicated that only 50 per cent showed zero readings on the pneumophone. An average figure was —2.4 cm. for the series. Borg examined 600 children with the pneumophone and found that 75 per cent showed a reading below 5 cm. This suggested that a slight degree of tubal stenosis may be present even in the so-called normal ear. Previously Van Dishoeck had reported negative readings in otherwise normal ears after adenoid and nose operation, in the presence of an upper respiratory infection, greater frequency of negative readings in the winter over the summer, etc. He found that an acute tubal stenosis may show a reading of —50 cm. and require 15 days to return to a —5 cm. reading, but immediately after each inflation a zero reading could be obtained. He found that

in chronic tubal stenosis a constant large negative reading was obtained, which could only momentarily be corrected by inflation. The average rate of return to the preinflated condition was about 5 cm. per hour. He differentiated between chronic stenosis with exacerbations of exudative catarrh and chronic stenosis with recurring suppurative otitis. The validity of the observations described above rested upon two assumptions: One was that the pressure of the air in the middle ear was reduced in pathological conditions of the tube; the other, that the apparatus devised was able to detect this reduction of pressure. The existence of negative pressure in the middle ear is still doubted by some otologists. A discussion of this point occurred recently in the literature between Blegvad[9] and Holmgren.[10] The former claimed that this did not occur, while the latter reported experimental work in corroboration of a long-standing theory advocated by Politzer that reduction of middle ear pressure did take place in tubal obstruction. Blegvad stated that he never saw a stream of air bubbles going into the middle ear through the fluid of a catarrhal ear when doing a paracentesis. This observation was reported by Politzer. In a patient recently treated in this clinic a similar observation was made — on incising the drum in catarrhal otitis. Canfield[11] has also reported this observation in artificially produced aerotitis. To study this problem further experimental observations on normal subjects were made in a pressure tank. Known controlled amount of relative negative pressure in the middle ear could be made at will by having the subject ventilate his ears after reducing the pressure in the tank a known amount, *i.e.*, from 760 to 740 mm. Hg. Then the tank pressure was brought back to 760 while instructing the subject not to swallow or otherwise to ventilate his middle ear. Now the middle ear air remained at 740 mm., or 20 mm. below the external air. A sense of stuffiness in the ear was noted because of the suddenly created pressure difference — and with this controlled pathological state prevailing, the pneumophone apparatus was used. It was thus possible to assess the ability of this apparatus to detect this artificially created negative middle ear pressure and to do this quantitatively. The static pressure developed with the hand bulb needed to produce maximum loudness was

found to be equal to the known pressure difference between the two sides of the drum. This demonstrated the value of the apparatus for investigating this particular abnormality of the physical state of the conduction apparatus.

The interpretation of results obtained with this apparatus in the clinic is more difficult since the physical state of the middle ear is not known. The particular acoustic property that is investigated is that of stiffness. Inequality of air pressure between the two sides of the drum is not the only cause for an abnormal degree of stiffness of the conduction mechanism. Middle ear muscle effects may be considered as well as adhesions and contractures all along the conduction mechanism from the drum to the oval window. Many of these are likely to be irreversible lesions not affected by inflation. Observations on acute reversible lesions are most easily interpreted. Several instances of this type are described below, along with observations on chronic lesions of the middle ear. Before proceeding with these reports, a brief description of the apparatus used for this study is indicated (see Fig. 1).

A cheap telephone earpiece from an old radio headphone was made airtight with sealing wax. To the central hole in the receiver cap was sealed a short fibre tube. Before this, the cap was removed and the metal disc over the pole pieces was perforated in several places so as to insure equality of pressure on both sides of the disc when making pressure changes with the hand bulb. If this was not done, the operation of the disc itself might be affected and a change in the sound output at the source would occur. The tube in the telephone cover was then connected to a small metal chamber from which a number of openings led. One was connected through tubing to a small rubber atomizer bulb. This bulb has a ball valve at its end and when suitably held can be used to make and retain small alterations of static pressure in the system. These pressures were measured by a connecting water manometer marked off in centimeters. An earlier model used in this study contained a mercury manometer.[12] The small changes in pressure for the pneumophone operation alone were in the order of millimeters of mercury and, there-

fore, difficult to read. The water manometer made it easier to read the pressures developed, since they were in the order of centimeters of water. To facilitate visibility of the manometer, the water was colored with methylene blue. In addition to the manometer and hand bulb connections to the small metal chamber, there was a connection for the delivery of

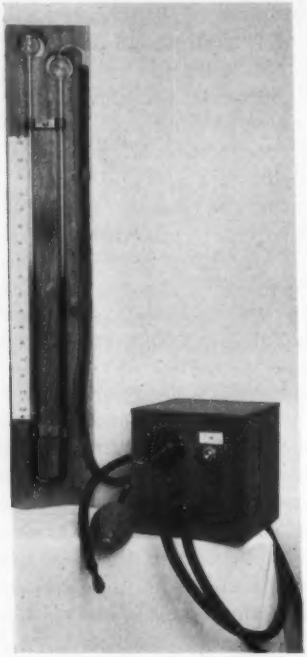


Fig. 1. Illustration of the apparatus used to evaluate the stiffness function of the conduction apparatus.

sound to the patient's ear through rubber tubing. Stethoscope tubing was used throughout. An oval hard rubber earpiece was found most satisfactory in getting an airtight connection with the patient's external auditory canal. The telephone earpiece was actuated by the 60 cycle fluctuations in the ordinary electric line and a satisfactory voltage reduction was obtained by using a 2000 ohm resistance in series with the receiver. This resistor was found by trial to generate only as much

heat as could be satisfactorily dissipated by the surrounding air. The use of such a resistance eliminated the need for a transformer such as was used by Van Dishoeck in his apparatus. The poor response characteristics of the receiver was an advantage in this test since it delivered a 60 cycle tone with many harmonics. Not only loudness changes could be detected but also changes in tone quality as the result of preferential alterations in the function of the conducting mechanism as a function of frequency. In addition, a variable resistance was used to regulate the sound intensity.

The apparatus was used as follows: A tone of moderate loudness was produced — the patient altering the intensity by moving the dial on the variable resistance until the sound was a little above his threshold. If the sound was too loud a fatigue factor would be introduced when the ear tip on the sound conducting tube was fitted snugly into his external canal. He was then told to watch the left-hand column of the water manometer, behind which was placed a scale marked off in centimeters, and to note any changes in loudness when the static pressure changes were rapidly made. If any change occurred he was to indicate at what level of pressure maximum loudness was experienced. The loudness change was more readily noted because of its rapid fluctuation. Very slowly (minutes or hours) produced loudness changes would be more difficult to sense. The hand bulb was adequate to develop these small pressure changes. It was found from previous experience that the maximum pressure changes needed for this examination was about plus or minus 50 cm. of water. The speed of the pressure changes could be well controlled and the pressure maintained at any desired level, if the earpiece made an airtight connection with the patient's canal. If a leak occurred during the test, the changed response of the manometer to the pressures developed at the hand bulb were easily detected. An airtight system was needed not only to maintain pressure changes but to insure against leakage of sound out of the canal with the resultant changes in loudness especially important for low frequency sounds. A patient with normally functioning and normally ventilated middle

ear will note decrease in loudness when the pressure is altered plus or minus 1 to 2 cm. of H_2O.

Pressure changes made by the patient himself: A normal middle ear may retain about 15 mm. Hg. of positive pressure before the tube will be blown open. A smaller amount of positive pressure can be trapped in the middle ear for a short time during Valsalva's maneuver. This is seen as a bulging drum and the amount of pressure can be measured with the pneumophone by a measured amount of positive pressure being delivered to the external surface of the drum to obtain maximum loudness of the sound.

Conversely — a small amount of negative pressure may be created by a subject during Toynbee's maneuver (swallowing with nose closed). The drum may be retracted and again the amount of negative pressure can be measured with the pneumophone. The manometer records the amount of negative pressure needed on the external surface of the drum to obtain maximum loudness.

ACUTE LESIONS.

In the course of investigations in the physiology of flight a pressure tank was in use at the hospital. Flight conditions were simulated and human subjects were used as test material. Several of these subjects on occasion developed sufficient ear symptoms in simulated descent on leaving the tank—they were sent to me for an otologic evaluation. Studies were made on subjects shortly after leaving the tank and at various intervals thereafter. Two illustrative cases are described.

Case 1: Subject K. March 7, 1944. Was taken up 38,000 feet with no difficulty and after a period was decompressed. This was difficult and required an hour instead of usual half-hour to return to atmospheric pressure. A little pain was noted in the ears, and a sense of stuffiness. When seen shortly after leaving the tank the drums were congested, dull and red. No fluid lines could be made out even with a Siegle otoscope. The pneumophone reading on the right showed that no change in loudness was noted between plus 20 and minus 30 cm. H_2O pressure. The ear was inflated, causing both the pars tensa and pars flaccida to bulge. Now a fluid line could be made out anterior to the malleus at the level of the umbo. The ear could not be deflated by swallowing with the nose closed (Toynbee's maneuver): an indication of tubal obstruction. After inflation the pneumophone reading showed optimum loudness at about minus 16 cm. H_2O. The end-point could now be easily deter-

mined by the patient (the difference in loudness with change of pressure was quite distinct).

March 8, 1944: The next day bloody mucus was expectorated and examination of the nasopharynx revealed bloody mucus at mouth of right Eustachian tube. A high fluid line anterior to the malleus was seen behind a dusky red drum. Shrapnell's membrane was retracted. After inflation air appeared behind and in front of the malleus.

March 13, 1944: Five days later, there was more air in the middle ear. The audiogram was improved. The pneumophone reading was minus 20 cm. H_2O and this returned to zero after inflation. Now the ear deflates spontaneously.

Case 2: Subject F. Jan. 14, 1944. Age 24. Two weeks before experiment he had "flu." No sense of obstruction or discharge. He went up to 10,000 feet in the pressure tank for one hour and when coming down the ears "stopped up"; went up again immediately without relief of obstruction. The next day he went up again. Popping and crackling sounds were noted in his ears but no complete clearing. Coming down, he again noted these sounds with no pain or pressure, but continued stuffiness since then.

Drums dusky, retracted, red. Fluid lines behind right drum.

Minus 20 cm. H_2O pneumophone reading bilateral; greater negative pressure reduces loudness.

Double plus fluid bubbles seen behind both drums after inflation.

Cannot deflate drums after inflation.

Jan. 18, 1944: Ears almost clear. Pneumophone: minus 20 cm. H_2O, right; minus 10 cm., left.

Both ears inflated. Then pneumophone reading was zero bilaterally.

Circular moisture lines seen behind right drum.

A small streak of bloody mucus seen behind left malleus handle.

All symptoms disappeared in the next few days, with return of pneumophone readings to zero.

Discussion: Acute barotrauma with the formation of submucous hemorrhage and swelling and the intratympanic accumulation of serosanguineous fluid may leave no air in the middle ear upon which alterations of external pressure can act. Thus no loudness change is noted with large differences of pressure. This observation holds true for patients with exudative catarrh where the middle ear is completely filled with fluid; *e.g.*, in carcinoma of the nasopharynx. Only the yellowish color of the drum and the thin, chalky white line of the malleus indicates the nature of the middle ear pathology in these cases. When such an ear is inflated a little air is dis-

tributed in the fluid and a fluid line may now be made out — usually at the mouth of the tube (anterior to the handle of the malleus). Sufficient air may be blown into the middle ear to be affected by external pressure changes and thus to permit changes in loudness with the pneumophone. A reduction of pressure in the external canal is often found to lead to an increase of loudness as more fluid leaves the middle ear. The air taking its place is usually at reduced pressure — leading to negative pneumophone readings. Inflation may now temporarily restore normal pressure relations and result in a zero pneumophone reading. As the tube restores normal pressure and the middle ear mucosa returns to normal thickness, the normal pneumophone readings of plus or minus 1 on 2 cm. H_2O return to stay.

Reversible negative pneumophone readings were found in a great variety of pathologic states of the upper respiratory system, such as:

Allergic rhinitis.

Carcinoma of the nasopharynx.

Retraction of Shrapnell's membrane.

Exudative catarrh.

Acute bullous myringitis.

Cleft palate.

Adenoid hypertrophy.

Upper respiratory infection.

It is significant that immediate but not sustained reversal of the pneumophone readings was usually obtained by inflation. As the acute pathological state was reversed, however, pneumophone readings did return to stay at the zero level. This suggests that a real phenomenon is being observed. The use of this method in studying patients with fluid in the middle ear is of interest. If the middle ear is completely filled with fluid no loudness change is noted with changes of pressure on the drum (this is comparable to a positive Gellé test

in otosclerosis). When such a patient begins to improve, air bubbles appear behind the drum. Now, consistent negative readings are obtained. In practically every case in which both air and fluid were present in the middle ear, negative readings were obtained. Upon inflation, these readings returned toward the zero level but in several hours again returned towards the previous negative pressure state. When the condition cleared up, zero readings were usual. In cases where repeated attacks of exudative catarrh occurred, negative pneumophone readings might continue between attacks. These findings suggest that a real phenomenon is being observed — and that we are measuring primarily the difference in pressure of the air gases between the two sides of the drum.

Information about chronic lesions of the stiffness factor of the conducting mechanism can also be obtained with this method. These can be divided into temporarily reversible and irreversible lesions as related to their reaction to inflation. A flaccid atrophic retracted drum, not adherent to the promontory, may be the end-result of long-standing earlier tubal stenosis. Permanent changes in the stiffness may thus continue after the tube has returned to its normal state. In such cases, a reduction in pressure over the external surface of the drum improves the stiffness characteristics of the conduction apparatus. Negative pneumophone readings, therefore, are commonly obtained in such cases. In addition, inflating such an ear may also restore the normal stiffness and return the pneumophone readings to normal, as long as positive pressure can be trapped in the middle ear. As much as 15 mm. Hg. positive pressure can be retained in the middle ear before the normal tube is forced open. The positive pressure, however, will leave the ear as soon as the patient swallows. The drum now returns to the permanently retracted position and again negative pneumophone readings are obtained. This is an example of a chronic, temporarily reversible lesion of the stiffness factor of the conducting mechanism. Stiffness lesions due to stretchable connective tissue bands about the incus and malleus might also be reversed temporarily by inflation. More advanced states of pathological stiffening may not be even temporarily reversible. If the created

middle ear or external ear pressures are not sufficient to affect the lesion — no change in loudness is noted by the subject. An interesting example of this is severe otosclerosis. The Gellé test can easily be made with this method and a positive test can be obtained suggesting severe stapes fixation. Permanent negative readings are sometimes obtained that cannot be reversed by inflation. The small amount of positive pressure trapped in the middle ear may be inadequate to overcome the middle ear stiffness lesion. The negative pressures created on the external surface of the drum with the pneumophone may, however, be great enough and momentarily overcome this lesion; therefore, this would result in the subject's noting an increased loudness of the delivered sound when the necessary negative pressure is created in his external canal.

SUMMARY.

Information about the normal and pathological function of the middle and Eustachian tube can be obtained by the use of the method described. It permits an evaluation of the factors affecting the stiffness property of the conducting mechanism. Observations made with this method in the otologic clinic should lead ultimately to a better understanding of the function of the Eustachian tube and the acoustic properties of the conducting mechanism as concerned with reversible and irreversible lesions affecting the stiffness function.

BIBLIOGRAPHY.

1. Van Dishoeck, H. A. E.: Das Pneumophone. *Arch. f. Ohren., Nasen. u. Kehlkoph.*, 144:53-58, 1937.

2. Griesman, B.: New Methods of Testing Hearing. *Beit. Anat. usw. Passow and Schaefer*, 16:52-53, 1931.

3. Pohlman, A. G., and Kranz, F. W.: The Effect of Pressure Changes in External Canal on Acuity of Hearing. *Ann. Otol., Rhinol. and Laryngol.*, 32:545-553, 1923.

4. *Ibid.*: The Problem of Middle Ear Mechanics. *Ann. Otol., Rhinol. and Laryngol.*, 34:1224-1238, 1925.

5. Bekesy, G. V.: Theory of Hearing by Bone Conduction. *Annalen der Physik*, 13:1:128-134, 1932.

6. Van Dishoeck, H. A. E.: *Koninklijke Nederlandsche Akademi Van*

Wetenschappen, 43:1, 1940. Proceedings. Der Einfluss von Luftdruckvariationen auf das Gehör Luft und Knochenleitung.

7. Van Dishoeck, H. A. E.: Negative Pressure and Loss of Hearing in Tubal Catarrh. *Acta oto-laryngol.*, 29:4:303-312, 1941.

8. Van Dishoeck, H. A. E.: Stenosis of Eustachian Tube. *Acta oto-laryngol.*, 32:346-352, 1944.

9. Blegvad, N. R. H.: Tubar Occlusion or Catarrh of the Middle Ear. *Acta oto-laryngol.*, 29:313-315, 1941.

10. Holmgren, L.: Tubar Occlusion. An Answer to N. R. H. Blegvad. *Acta to-laryngol.*, 29:313-315, 1941.

11. Canfield, N., and Bateman, G.: Myringopuncture for Reduced Intratympanic Pressure. *Jour. Aviation Med.*, 15:340-343, 1944.

12. Perlman, H. B.: Quantitative Tubal Function. *Arch. Otolaryngol.*, 38:453-465, 1943.

VOLUME CONTROL ADJUSTMENT IN HEARING AID SELECTION.

RAYMOND CARHART, Ph.D.,

Evanston, Ill.

I. – INTRODUCTION.

The better hearing aids of today have sufficient electroacoustic excellence so that most wearers can receive ordinary speech and other mid-intensity sounds moderately well with any adequate fitting; therefore, decisions on the relative merits of different instruments must be based on one or more of the following considerations: *1.* fine differentials in reception of mid-intensity sounds; *2.* distinctions in the performance limits which the wearer achieves; *3.* such features as "instrument noise," convenience, cost, maintenance and personal preference.

The current philosophy of hearing aid selection calls for the comparative testing of several promising instruments to determine both differentials in reception of mid-intensity sounds and differentials in performance limits. Many of the procedures which have evolved under this philosophy demand that conditions be equivalent for the various instruments being tested. Among other things, some procedures require that the volume (or gain) be adjusted to the same level.

The choice of a method for equating volume (gain) presents serious problems. The three possibilities which come to mind first have definite limitations. Thus, because the maximum electroacoustic gain varies from one model to another, one cannot equate instruments by setting them all at "full volume." Similarly, because of circuit differences and variations in the "taper" of the controls, one cannot equate instruments by moving the volume (gain) controls through a specified fraction (*i.e.*, one-half or two-thirds) of the total excursion. Finally, since hearing aids vary in the smoothness and range of their frequency response characteristics,

Editor's Note: This ms. received in Laryngoscope Office and accepted for publication, April 7, 1946.

attempts to equate volume (gain) by physical measurement are fraught with sufficient difficulty to be impracticable in clinical situations.

A fourth possibility, and a more feasible procedure provided sufficient reliability can be achieved, is to have the patient set the volume (gain) according to some specific criterion of experience. A logical psychophysical criterion is the *comfort level.* To achieve comfort level the patient adjusts the hearing aid so that a predetermined input signal is being amplified to the point where he judges the signal to be "most comfortable." Stated differently, it is the adjustment which he would prefer if he were going to listen to the sound for a long period.*

II. – THEORETICAL BASIS.

The rationale for the comfort level method is simple. It rests upon the assumption that in the typical life situation the hearing aid user wishes to follow a particular set of sounds, *i.e.*, a lecture, conversational speech, etc. Ordinarily, such sounds will not undergo extreme intensity variations and will be of moderate strength. Hence, the typical hearing aid user can expect to receive them adequately. He will, however, adjust the instrument so that he hears the sounds at the level which he judges most satisfactory (most "comfortable"). If he were to compare various instruments under these circumstances, he would set each at its most comfortable level. Thus, *from the standpoint of the individual, identical comfort level settings constitute equivalent volume (gain) control adjustments.* The method does not imply that electroacoustic equivalence has been achieved; instead, it stresses functional equivalence. Under conditions of functional equivalence, any significant performance differences which exist between instruments may be assumed to delimit the dimensions which determine *for the wearer* the relative practical efficiency of each hearing aid.

*Monitored speech offers a convenient stimulus on which to base a comfort setting. Experience has shown that an input of 40 db. above normal threshold is feasible, yet rather exacting for most hearing aid users.

III.– APPROACH TO THE PROBLEM.

While the theoretical basis for the comfort level method is simple, one is justified in employing the method in test procedures only if it can be demonstrated to have sufficient precision to yield results which are meaningful. The present paper is concerned with this problem. It presents statistical analyses of data gathered when the comfort level was used routinely in the selection of hearing aids for hard-of-hearing patients.

Two questions bearing on the clinical usefulness of the method are considered:

1. Do patients with impaired hearing show sufficient *reliability* with the comfort level method to justify its use for adjusting the volume (gain) control?

2. If they do show sufficient reliability, what *precautions* in use and interpretation are necessary?

A third question, and one bearing on the application of the method to hearing aid selection, is also explored; namely, when modern hearing aids are compared at the same comfort level, are the aided thresholds obtained with them significantly differentiated? In other words, are discrepancies in "residual loss for speech" thus revealed great enough to be due to actual difference in the performance which the individual patient achieves with the various instruments?

IV. – STATISTICAL DATA.

The final stage in the hearing aid selection program at Deshon General Hospital consisted of a Hearing Aid Evaluation, in which the three instruments most promising for a patient were each subjected to a battery of tests.* As part of this battery, aided thresholds were obtained when the various instruments were set at comfort level.* Two independent

*Carhart, R.: The Selection of Hearing Aids. Arch. Otolaryngol. (in press).

*Ordinarily, monitored speech at 40 db. above normal threshold was the input signal presented to the hearing aid. The volume (gain) setting which brought the patient this signal most satisfactorily was termed the "40 db. comfort setting." The term was appropriately changed when circumstances called for the use of some other input level.

measurements, based on independent adjustments, were made with each instrument. From the data thus obtained it was possible to compute for each patient two kinds of information: *1.* the difference for the same instrument between the first and the second "residual loss for speech," and *2.* the discrepancies between thresholds obtained with different instruments.*

The statistical analyses described below are based on results yielded by a sample of 413 patients. The sample was random except for two selective factors. First, the sample did not include patients whose hearing was sufficiently good so that they had already been eliminated from the program because a hearing aid was judged unnecessary; second, it was decided for statistical reasons to limit the data to measures obtained at the 40 db. comfort setting. Furthermore, in order to avoid loading the data in favor of high reliability, it was required that the 40 db. comfort setting be achieved without adjusting the instrument to full volume. Thus, patients who, because of extreme loss or other reason, could not achieve the 40 db. comfort setting or could achieve it only at full volume were excluded; however, in order to give a wider sampling of patient types, it was not necessary for the patient to meet the above specifications with all three instruments. When a patient did not meet such specifications, the only measurements included for him were those on which the specifications were met.†

All aided thresholds ("residual losses") were determined by standard speech reception techniques with the Harvard bisyllabic words (spondees). The material was presented by monitored live-voice through a loud speaker. The hearing aid under test was mounted at a fixed point on a baffle. The baffle was a sheet of acoustic tile which was one foot square. The loud speaker was across the room from the baffle. The test

*Hearing aids manufactured by nine companies were available and were used with varying frequency.

†The number of comparisons between measures, therefore, varied somewhat from one analysis to another and depended upon the limitations imposed by the analysis. Except for Sections IV 2 and IV 3, as many comparisons were included as allowed by the limitations of the moment.

chamber was soundproof and highly sound treated. Connected speech (40 db. above normal threshold as received at the baffle) was introduced through the loud speaker. The patient adjusted the instrument under test to bring in this signal "most comfortably." The "residual loss," or aided threshold, was then determined by the monitored live-voice technique.

1. Consistency of Repeat Settings.

One criterion of the reliability of the comfort level method is the consistency with which patients in a clinical situation can repeat the same setting with the same instrument.

The data at hand allow indirect assessment of the consistency of repeat settings. To explain: One may reason that a difference between the two aided thresholds for a single instrument represents a difference in "gain for speech" between the two settings and, hence, a difference in electrical gain. Electrical gain, in turn, is dependent upon volume control adjustment. Thus, the difference between the two thresholds gives an estimate of the degree by which the volume (gain) control adjustments deviate from each other.*

Fig. 1 summarizes the consistency of repeat settings as observed for 1,219 comparisons. The results are presented in terms of the difference (in decibels) between the two aided thresholds. As an arbitrary convention, the second "residual loss" was always subtracted from the first. Thus, a positive difference indicates that the second threshold was the better of the two, and vice versa.

Examining Fig. 1, one notes that the mean difference was 0.43 db. and the median difference was 0.23 db. The standard deviation of the differences between repeat thresholds was 3.91 db. Thus, the usual expectation from the foregoing data is that the second "comfort level threshold" would deviate not more than 4 db. from the first. Actually, in the data here presented, 82 per cent of all differences fell between +4 and —4 db.

A reliability of ±4 db. is relatively high for a clinical situ-

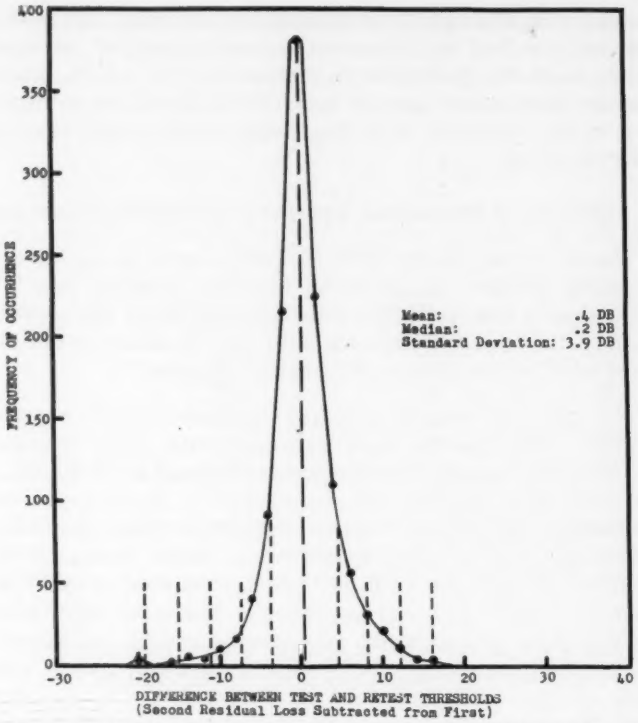


Fig. 1. Distribution of test-retest differences between aided speech reception thresholds obtained with two independent settings at 40 db. comfort level. Based on 1,219 comparisons obtained with 413 patients. Each score obtained with a single hearing aid, but nine brands of instrument employed in study.

ation. The accuracy which we expect from good routine audiometry is ±5 db. Thus, it seems fair to conclude that *the comfort level method has sufficient reliability to justify its use as a clinical means of setting volume control on a psychophysical basis.*

Another estimate of the reliability of the comfort level

*The line of reasoning ignores the fact that the speech reception technique is not completely reliable. Some variation in repeat threshold is to be expected because of the testing tool employed. When one assumes that all of the observed variation is a function of difference in volume control settings, one is erring on the safe side and is claiming less reliability for the comfort level method than it may possess.

method was obtained by computing the test-retest correlation between the first and the second measurement of "residual loss." Here the coefficient of correlation was +0.87, which may be taken as evidence of high reliability and as confirmation of the conclusion that the comfort level method is clinically adequate.

2. Influence of Instrument Position in Evaluation Sequence.

Where several hearing aids are being tested consecutively, a second problem of reliability appears: namely, does an instrument's position in the total sequence affect the consistency of the repeat thresholds with it? In other words, do experience factors exert a differential influence?

The problem was investigated through records on 175 patients. The results were arranged into three groups: *1.* differences between the two scores obtained at 40 db. comfort level with the first instrument tested; *2.* differences with the second instrument; and *3.* differences with the third instrument. When these three groups were compared by Analysis of Variance, an **F** of 2.86 emerged under conditions where 3.02 had 5 per cent significance. The mean differences for the three groups were, respectively, +0.35, +0.61 and —0.23 db.; however, **t** tests revealed that the second and third groups were distinguished at almost the 1 per cent level. The separation between the means for these two groups was 0.84 db. Thus, a definite but numerically small systematic distinction probably characterized the patient's reactions on setting the second instrument as opposed to the third. Since the differential is much smaller than the margin of uncertainty (±4 db.) mentioned earlier, the effect of instrument position on consistency of comfort level adjustment can ordinarily be ignored in clinical applications and is not a major limitation.

3. Influence of Talker.

Another question arises when comfort level settings are made and thresholds are obtained with live-voice stimuli:

namely, do repeat thresholds vary from one "talker" (tester) to another? The problem was investigated by grouping 708 test-retest comparisons according to the "talker" who administered the test material. The results obtained by seven trained "talkers" were included.

TABLE 1.

Mean of Difference, According to "Talker," Between Thresholds Obtained on the First and on the Second 40 Db. Comfort Level Setting with the Same Hearing Aid.

Talker	Number of Comparisons	Mean of Differences in Decibels	Standard Deviation in Decibels
1	119	—0.71	2.8
2	99	—0 31	3.9
3	88	—0.25	3.9
4	155	—0.05	3.4
5	80	0.16	3.9
6	99	0.65	2.9
7	68	1.74	5.7

Table 1 summarizes, by "talker," the means of differences (between test-retest) and the standard deviations of these differences. One notes that both statistics vary from tester to tester.

When the data were subjected to Analysis of Variance, an **F** of 3.75 emerged under conditions where 2.85 has 1 per cent significance. The **t** ratios comparing individual "talkers" with one another showed the mean for Talker 7 to be significantly separated from means for all except Talker 6. Talker 6 showed significant separation from Talker 1. All other **t** ratios were below 5 per cent significance.

The importance of differences between the standard deviations for the various "talkers" was assessed by determining **t** ratios. The standard deviation for Talker 7 was distinguished at well beyond 1 per cent significance from the standard deviations for all other "talkers." Talkers 1 and 6 were similarly distinguished from Talkers 2, 3 and 5. The standard deviations for Talkers 1 and 4 were differentiated at the 5 per cent level. All other **t** ratios were well below 5 per cent significance.

The foregoing results show clearly that the relation between test-retest thresholds based on comfort level settings vary from one "talker" (tester) to another. It is, therefore, clear that when the comfort level method is used with live-voice procedures, clinical findings must be analyzed to determine and allow for "talker" (tester) influence. Both the direction of any systematic trend and the standard deviation of differences between test-retest thresholds must be ascertained. In general, "talkers" will probably yield results which conform satisfactorily to the statistics for a large sample, as already reported in Section IV 1; however, the validity of this assumption must be confirmed locally before it can be accepted for a new clinical situation.

4. Threshold Differences Between Instruments.

Since clinical use of the comfort level method involves a small but definite margin of error, a practical question presents itself: namely, are the differences in threshold observed between instruments (which have been set to the same comfort level) sufficiently small so that they can be accounted for on the basis of the margin of error in the method itself? If the answer is positive, different hearing aids fail to show sufficient variation in "residual loss for speech" to make the determination of this measure meaningful on the basis of comfort level settings. In fact, if the answer is positive, true variations in "residual loss" are probably so small that they have no practical importance.

The question was investigated by analyzing discrepancies between "residual loss" thresholds obtained with different hearing aids. Discrepancy Scores were computed for each patient by arbitrarily subtracting the first threshold for the instrument tested later from the first threshold for the instrument tested earlier.

Fig. 2. presents the distribution of Discrepancy Scores for 1,147 comparisons between instruments. The mean of Discrepancy Scores was +2.5 db. and the median was +1.9 db. The results indicate a systematic trend toward slightly

better thresholds on instruments used later in the evaluation sequence. The systematic displacement probably resulted from a learning factor which operated in the test situation.

The most important feature of the distribution, however, is the fact that the standard deviation of the Discrepancy Scores was 6.7 db. Here is a value indicating considerably greater dispersion between instruments than occurred on test-

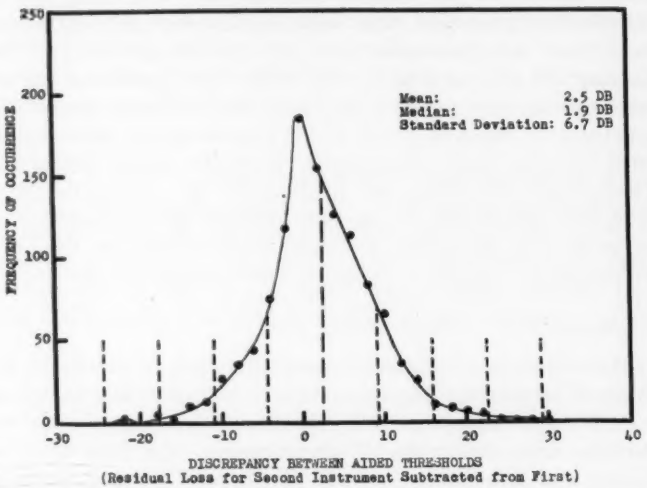


Fig. 2. Distribution of discrepancies between aided speech reception thresholds obtained with two different hearing aids, each set at 40 db. comfort level. Based on 1,147 comparisons obtained with 413 patients. Nine different brands of instrument employed in the study.

retest with a single instrument (where the standard deviation was 3.9 db.). The statistical significance of the dissimilarity in dispersion is high, being represented by a **t** ratio of 17.4. One may, therefore, state that in many cases the difference between instruments was sufficiently great so that it could not be accounted for on the basis of the variability inherent in the comfort level method. To the writer, *it seems a fair conclusion that in such cases real differences in instrument performance* (as used by the patient) *were also present;* however, in reaching such a conclusion one must not lose

sight of the total statistical picture. In many cases differences were so slight that no distinction could justifiably be made between instruments on the basis of thresholds obtained at comfort level settings.

Another reason for believing that many discrepancies between instruments are due to more than inaccuracies in the comfort level method appears in the correlation between the aided thresholds for various instruments. The coefficient of correlation was +0.62. The result has a value sufficiently high to indicate that the patient who gets good thresholds with one hearing aid will tend to do well with other promising instruments (and vice versa); however, the coefficient is sharply less than the value of +0.87 which represents the interdependence between two adjustments with the same instrument (test-retest reliability, see Section IV 1). Thus, the shift from one instrument to another reduces the correspondence between two measures. It seems safe to assume that this reduction is a function of actual performance differences.

5. Magnitudes of Differences.

If one disregards the direction of the shift in threshold, the mean difference for the test-retest data (1,219 comparisons) is 2.67 db. The companion mean for Discrepancy Scores between instruments (1,147 comparisons) was 5.24 db. Sixty-two and five-tenths per cent of the latter scores exceeded the mean of test-retest differences, while only 14 per cent of the test-retest differences exceeded the mean for Discrepancy Scores. Analysis of Variance revealed the two means to be significantly distinctive, as shown by an **F** of 64.3 where 6.66 allows 1 per cent confidence. Thus, from the standpoint of the amount of discrepancy (disregarding direction), here is strong evidence that the differences observed between instruments are meanfully greater than the discrepancies due to patients' inabilities to repeat the same comfort level perfectly.

V. – CLINICAL INTERPRETATION.

Skepticism as to the clinical value of the comfort level

method is expressed in an NDRC analysis of hearing aid selection.* The main points in this skepticism are as follows:

1. In order for the method to be practical, comfort level settings must be capable of consistent repetition (must have high reliability). Otherwise, ". . . true differences in the effectiveness of various instruments may be canceled or even reversed". . .

2. After experimentation with both normal and hard-of-hearing subjects, the NDRC group was convinced that comfort level settings are sufficiently variable ". . . to vitiate any differences which might reasonably be expected between instruments. . ."

3. There is no ". . . clear-cut evidence that the method actually does discriminate usefully". . . , in terms of "residual loss for speech," among well fitted modern hearing aids. At best the method only allows one to ". . . detect and reject any very inferior instrument . . . ," which presumably could be isolated more easily in a preliminary screening stage.

The NDRC position presents an interwoven consideration of two problems which are often interdependent but which need to be recognized separately. The first problem is whether or not consistency of comfort level settings is great enough to justify use of the method. The second problem is whether present-day hearing aids (when well screened in terms of patient needs) show sufficient differences in "residual loss for speech" while set at the same comfort level to warrant basing selection (at least in part) on observed differences in "residual loss for speech."

The present paper is concerned primarily with the first problem, since comfort level settings can be used in conjunction with techniques other than "residual loss for speech." While the statistics given earlier reveal a margin of error (due to a variety of factors) in the comfort level method, the surprising fact is that the margin proved so narrow. The

*Davis, H., and Ross, D. A.: Selection of Hearing Aids (Cambridge, Mass.: Psychoacoustic Laboratory), pp. 32-35, Dec. 31, 1945.

error is well within the limits which are ordinarily accepted when auditory measurement is conducted in clinical situations. It is, therefore, the writer's opinion that the comfort level method has sufficient clinical consistency to justify its use as a means of equating volume (gain) when appropriate precautions are taken.* The method may be employed in any procedure, including measurement of "residual loss for speech," where reasonable control over volume (gain) setting is desired.

The statistics reported in Sections IV 4 and IV 5 throw some light on the second problem, namely, the value of "residual loss for speech" as a means of discriminating between promising hearing aids. Greater variability and discrepancies of larger magnitudes occurred between instruments than were observed for repeat settings on the same instrument. Since high levels of statistical significance were evident, one may conclude that even promising instruments frequently show differences in "residual loss" which cannot be accounted for as entirely due to the margin of inaccuracy resident in the comfort level technique. Clinical experience leads the writer to believe that such differentials often represent true performance differences between instruments.

For convenience in discussion, we may assume from the statistics given above that differentials between instruments are of three types: *1.* Discrepancy Scores so small that they must be considered as representing only the margin of error of the comfort level method; *2.* Discrepancy Scores large enough so that there is some evidence in favor of one hearing aid; and *3.* Discrepancy Scores so large that the weighing is

*In fairness to the NDRC views, it should be remembered that the data analyzed above employed the method of "residual loss for speech" in assessing the consistency of the comfort level technique. In other words, it was assumed that the gain for speech (i.e., difference between unaided threshold and "residual loss") was proportional to the instrument's electroacoustical gain under the conditions of test. On this assumption, differences in "residual loss" obtained with the same instrument were taken to represent differences in electroacoustical gain. There is possibility that the assumption is incorrect. For example: if each patient tends to have a limiting threshold which is somewhat independent of gain, the "residual losses" would be compressed into a narrower range than that of the electroacoustic gains with which the thresholds were achieved. The end-result would be spuriously low variability on test-retest results. The author has analyzed clinical data in several ways to explore this (and other) possibilities. So far he has found no evidence which throws doubt upon the assumption underlying the discussion in this paper.

sharply in favor of one instrument.* From the clinical point of view, the important thing is to assign each patient's results to the appropriate category. Two methods exist for doing so.

In the first place, one may assign scores to appropriate categories in terms of group statistics alone. For example: One might reason from the present study (where approximately two-thirds of the Discrepancy Scores between instruments were 6.7 db. or less) that a difference of 8 db. or more is strongly presumptive of a real differential between the hearing aids tested. Such a judgment, however, is at best a shrewd guess.

The second procedure recognizes the fact that the magnitude of any variation between instruments depends in part upon the patient's consistency in making comfort level settings. One may, therefore, refine the assessment by obtaining an estimate of the individual's reliability in making comfort level settings. Such a process tends to locate the patient in the total group. Theoretically one should compute the standard deviation of test-retest differences for the individual, but practical considerations make such a procedure prohibitive in clinical work. A feasible alternative is to obtain "residual loss" measures twice with every instrument, each measure being based on an independent comfort level setting. If three instruments are under test, one thus has three sets of test-retest thresholds which can be interpreted in terms of the statistics given in Section IV 1. When there is high correspondence within each test-retest pair, one is probably justified in assuming that the patient is consistent in comfort level settings. In such a case, differences between instruments of less than 8 db. can often be accepted as real. By contrast, when there is high variability within each test-retest sequence, one must assume that the patient is not consistent in comfort level settings. In such a case, differences between instruments of more than 8 db. have to be disregarded.

The procedure just outlined has proved effective at Deshon General Hospital in comparing different instruments on

*Actually, of course, the three conditions represent convenient reference points in a continuum from no significant difference to extreme difference.

"residual loss for speech." To be sure, not all patients show differentials on "residual loss" which allow choice to be made between instruments. In fact, the majority achieves relatively comparable results with several instruments (when appropriate preliminary screening has been practiced). *A substantial minority, however, reveals differences of sufficient magnitude to constitute a legitimate basis for selecting one instrument over others.* Measurement of "residual loss for speech," therefore, should be included in every careful exploration of hearing aid performance, at least until simpler or more precise methods for isolating the latter type of patient are available.

A further comment on the selection of hearing aids is in order. The clinical approach to the problem of selection must take cognizance of two things: First, there are several "dimensions" of hearing aid performance, any one of which may be critical insofar as a particular patient is concerned. The patient, therefore, needs to be protected by an exploration of all the important dimensions.* In the second place, interpretation of results must be in terms of the environmental significance of each performance score.† To illustrate: if all "residual losses" are less than 10 db., differences between hearing aids may be judged real and still not considered as important from the standpoint of everyday demands on the wearer. (The normal ear is seldom, if ever, required to distinguish speech at levels fainter than 10 db.). On the other hand, when all "residual losses" are greater than 30 db., a significant differential between instruments may assume primary importance as an indication of the practical usefulness the wearer may expect. Intermediate results call for intermediate interpretation.

The clinical fact which must not be ignored is that patients do vary widely from one another in the performance effi-

*One plan incorporating a series of steps to accomplish this end is reported in Carhart: Op. cit.

†Although such interpretation is arbitrary, in that it involves reasoning from a test situation to the presumed performance in "analogous" everyday situations, the procedure is clearly superior to judgments based on non-controlled observations. The assumptions of analogy which underly interpretation of each type of measure should, of course, be confirmed insofar as possible by clinical experience and experimental check.

ciency they achieve on all major types of measure, including "residual loss for speech." It is, therefore, important to make judgments based on a combined consideration of *1.* the level of efficiency the wearer achieves, and *2.* the details of variation between instruments. The total picture presented by the patient must be weighed before advising on whether a single instrument or one of several will fill the patient's need satisfactorily. A broad clinical procedure is required to abstract the varied facts which contribute to the picture.

VI – SUMMARY.

The comfort level method offers a psychophysical procedure for equating the volume (gain) settings on different hearing aids. Data on "residual loss for speech" obtained at equivalent comfort level settings were analyzed statistically with the aim of defining the reliability and limitations of the comfort level in a clinical situation. The data were taken from Hearing Aid Evaluation Tests administered to a routine series of 413 hard-of-hearing patients. Both the differences between repeat measures on the same instrument and discrepancies between instruments were analyzed.

The following findings and conclusions resulted:

1. The test-retest reliability of the comfort level method was high, as revealed by a correlation of $+0.87$ and a margin of uncertainty of approximately ± 4 db. Since these figures compare favorably with reliabilities for other clinical procedures in audiology, *it would seem that the method is a justifiable clinical means of setting volume (gain) on a psychophysical basis.*

2. For practical purposes, the position of an instrument in the test sequence did not affect the reliability of comfort level settings.

3. The reliability of comfort level settings varied significantly from one "talker" (tester) to another. One concludes that, when the monitored live-voice method is used, the influence of each "talker" must be defined by an analysis of clinical findings.

4. Discrepancies in "residual loss for speech" showed significantly more variability and numerically greater differences between instruments than did test-retest thresholds obtained with the same hearing aid. One concludes that in many cases discrepancies between instruments are due in part to a real performance differential.

5. There was some interdependence between the aided thresholds obtained with various hearing aids ($r = +0.62$); however, this trend was not contradictory to the basic conclusions of the study.

6. In clinical practice, the significance of discrepancies in "residual loss for speech" can be estimated with greater surety by assessing each patient's individual variability. A good procedure is to determine the aided threshold twice with each instrument. When this is done, the measurement of "residual loss for speech" based on equivalent comfort level settings often reveals differentials which may be taken as one basis for choice among hearing aids.

Northwestern University.

REINNERVATION OF A PARALYZED VOCAL CORD.*†

JULIUS W. MCCALL, M.D., and NORMAND L. HOERR, M.D.,
Cleveland, Ohio.

This paper is a preliminary report on the results, in the experimental animal, of nerve suture after vocal cord paralysis. We also propose a method for regeneration of the recurrent laryngeal nerve by means of anastomosis to the vagus nerve.

Paralysis of one vocal cord only does not endanger life. Voice weakness, voice change and frequent clearing of the throat characterize this condition. Pressure on the vagus or recurrent laryngeal from a tumor in the neck or mediastinum is a frequent cause of vocal cord paralysis.

Paralysis of both vocal cords does endanger life, for if both cords are paralyzed they assume the median position, closing the glottis. The paired posterior cricoarytenoids are the only abductor muscles of the larynx and, when they are paralyzed the patient cannot open the glottis on inspiration. If the cricoarytenoids do not open the glottis on inspiration, the flaccid cords are drawn closer together by the inspired current of air, causing the inspiratory crowing sound which is typical of bilateral abductor paralysis. Thus, it is an inspiratory dyspnea. The patient has no difficulty with expiration, as the force of the current of air is strong enough to separate the flaccid cords enough to expel the air.

Contrary to general belief, there is little voice change in bilateral abductor paralysis. There is not as much voice alteration in bilateral vocal cord paralysis as in unilateral paralysis, because in bilateral paralysis the vocal cords assume the median position.

Thyroid disease and sequelae of thyroidectomy are the most

*Read in abbreviated form at the Meeting of the Ohio State Medical Society, Columbus, Ohio, May 8, 1946.
†From St. Luke's Hospital, Cleveland, Ohio, and the Department of Anatomy, Western Reserve University School of Medicine.
Editor's Note: This ms. received in Laryngoscope Office and accepted for publication, Sept. 4, 1946.

frequent causes of bilateral paralysis. Neurological conditions such as cerebral lues are the next most frequent cause. During a thyroidectomy, the recurrent laryngeal nerves may

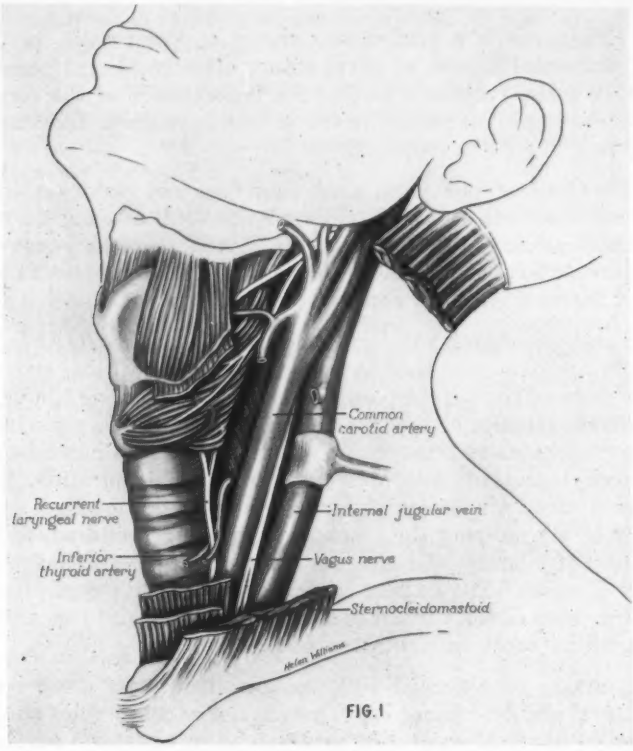


Fig. 1. Drawing of a dissection of an adult male human neck. The thyroid gland has been removed and the middle portion of the sternomastoid and infrahyoid muscles have been removed, in order to demonstrate more clearly the relationships of the recurrent laryngeal nerve. The carotid sheath has been dissected away and the internal jugular vein has been retracted laterally to expose the vagus nerve. The proposed method of suturing the recurrent to the vagus would involve bringing the vagus nerve medially, either over or under, the common carotid, and suturing it into the recurrent nerve as close to the larynx as possible. The figure also shows a common method of branching of the inferior thyroid artery, showing the close relation of its branches to the recurrent nerve.

be severed, or they may be so constricted by scar tissue postoperatively as to cease to function.

The right recurrent laryngeal nerve leaves the vagus and winds tightly behind and below the subclavian artery, and gains the interval between the trachea and esophagus on the right side of the neck. The left recurrent laryngeal nerve springs from the vagus, where the latter crosses the left side of the aortic arch. It then passes below the arch and up on its medial side to gain the interval between the trachea and esophagus. Because of its longer course in the mediastinum, it is more frequently affected by mediastinal tumor, enlarged glands and aortic aneurysm.

The recurrent laryngeal nerves (Grant, 1940) are closely related to the inferior thyroid artery; *1.* between the branches of the inferior thyroid artery in 65 out of 98 cases; *2.* entirely anterior to the artery in eight; *3.* entirely posterior in 25. It is easy to see how they can be injured in thyroid surgery, if a branch of the inferior thyroid is ligated.

The King and Kelly operative procedures for relief of bilateral abductor paralysis are well established. Either of these procedures necessitates a certain amount of mutilation of the larynx. If the breathing is improved, the voice is impaired. It occurred to us to attempt short-circuiting an injured recurrent laryngeal nerve by anastomosing the vagus to the recurrent peripheral to the lesion. If such an anastomosis could be accomplished, it would render a mutilation of the larynx unnecessary, and restore the normal function of the vocal cord.

In proposing this, we had to consider whether severance of the vagus nerve would endanger life. The vagus has been severed in the human in the attempt to relieve asthma, for the relief of gastric ulcer, and in esophagectomy; so we know that the vagus has been and can be severed in the human without noticeably untoward effects.

It is well known that the nerve fibres in a peripheral nerve pursue a slowly winding spiral along the course of the nerve. We do not know, therefore, exactly which fibres in the vagus nerve at the level of the cricoid cartilage constitute the fibres which will later go to make up the recurrent nerve. Also,

unless motor nerves can be sutured into the recurrent, any hope of returning function of the laryngeal muscles must be abandoned.

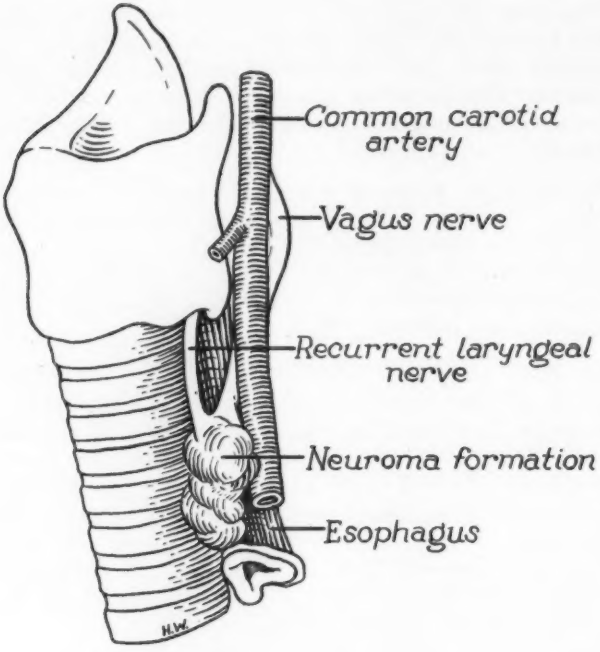


FIG. 2

Fig. 2. Sketch of the laryngeal and pharyngeal region of experimental animal No. 2. This animal was killed six months after operation. The vagus nerve had a winding course because it had been removed from the carotid sheath, and had been brought proximally after being cut low in the neck to loop it into the distal stump of the cut recurrent nerve. There was a neuroma hanging down from the point of suture. The muscles and vocal cord of the operative side appeared grossly similar to those of the unoperated side.

Accordingly, the anterior and median parts of the vagus nerve are sutured to the distal stump of the recurrent, to get some, at least, of the fibres originally constituting the recurrent branch of the vagus, so that regeneration of a sufficient

number of motor nerve fibres will occur for a return of motor innervation of the larynx.

The problem of reinnervating the laryngeal muscles in the experimental animal presents two questions: *1.* can the suture of the nerves and the regeneration of motor nerves to the muscles be accomplished within a sufficiently short period of time; *2.* can the central nervous system readjust so as to properly regulate the control of the laryngeal muscles through a new set of nerve fibres?

If, in the experimental animal, in which the recurrent laryngeal nerve and the vagus nerve are cut and immediately sutured, regeneration does not progress rapidly enough to insure return of function in the laryngeal muscles before they have atrophied, then there would be no point in attempting a restoration of function in the human. If, however, two inches of nerve, more or less, can be made to regenerate, develop new motor endplates and reactivate the muscles, then there is the possibility of applying the method to repair of paralyzed vocal cords in the human.

Obviously, the muscles must be innervated by motor nerve fibres; that is to say, regeneration of motor nerves must occur. It would be too much to hope for, however, to think that exactly the same nerves grow into the paralyzed muscles that originally innervated them; therefore, even if the first question can be answered in the affirmative, and nerve fibres do grow into the muscles within a short period of time, can the nervous system so adjust as to send the proper regulatory impulses over the new pathways?

The nerve fibres in the recurrent laryngeal nerve belong to the special visceral or somatic type; that is, they are the axons of neurons having their cells of origin in the nucleus ambiguus of the medulla oblongata, and they go directly to the muscles they activate. The other motor nerve fibres in the vagus are of the general visceral or sympathetic type for the most part; that is, they have their cells of origin in the dorsal motor nucleus of the vagus in the medulla, and they are the preganglionic fibres in a two-neuron peripheral path-

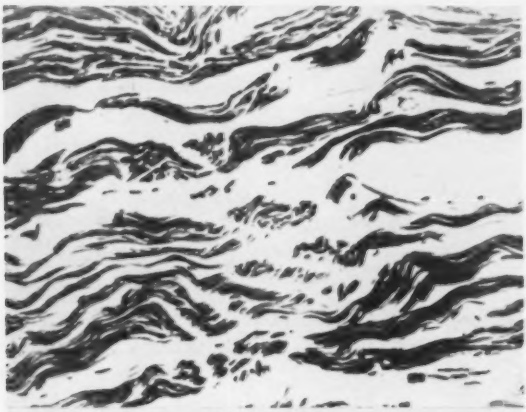


FIG. 3

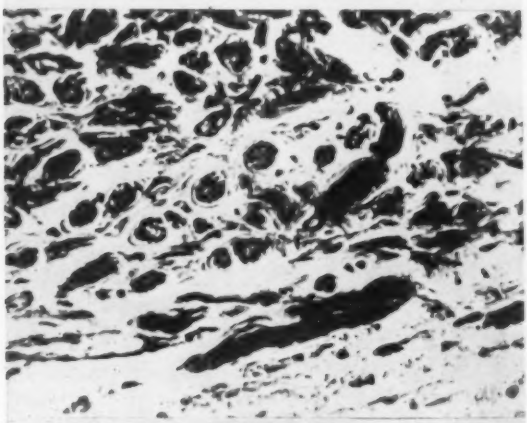


FIG. 4

Fig. 3. Portion of vagus nerve proximal to suture. It is difficult to get a longitudinal section of nerve fibres for any distance because of the extreme twisting of the nerve. Staining with Bodian's silver method shows the axis cylinders only. Magnification × 240. A H&E stain of a nieghboring section shows a great increase in the number of neurilemma nuclei.

Fig. 4. Bodian's silver stain, × 240, of the nerve distal to the suture. Small bundles of nerve fibres are imbedded in collagenous connective tissue. The scar tissue is much more evident in an H&E section, but the silver stain shows the nerve fibres to be anatomically continuous and normal in structure.

way; they do not directly innervate their muscles, but transmit their impulses to a postganglionic nerve call. The other fibres in the vagus, those which do not enter into the makeup of the recurrent laryngeal, for the most part activate smooth muscle, not striated muscle which is more or less under voluntary control.

It might be argued that even though we succeed in getting regeneration of motor fibres in the vagus to the muscles of the larynx, we could have no assurance that these muscles would ever be properly controlled by the brain. We had no means of knowing the answer, so we had to put the question to the test of actual experiment. We do not know the full answer as yet, but can only say that in three cases the paralyzed vocal cord is functioning in coordinated fashion, very like its normal counterpart on the unoperated side. There has been sufficient adaptation in the nuclei of the medulla to send impulses over the regenerated laryngeal nerve in response to activity of the motor cortex, as evidenced by a return to a normal bark in the case of one animal.

The answer to the first question is much more definite. In the experimental animal, at least, with a good suture of the anterior portion of the vagus into the distal stump of the cut recurrent nerve, the nerve fibres grow down and reactivate motor nerve endings in the muscles in five to 10 weeks, depending on the distance the regenerating fibres have to traverse.

The recurrent laryngeal nerve is usually injured in the region of the inferior thyroid artery, so we should find an approach to the recurrent nerve above where it had been severed or compressed. The recurrent laryngeal nerve leaves the groove behind the trachea and esophagus and turns lateral in the neck to enter the larynx just below the inferior cornu of the thyroid cartilage. This is above where it is usually injured. By making a collar (horizontal) incision about 1 cm. below the cricoid cartilage, beginning lateral to the sternomastoid on the side to be done and extending the incision across the midline of the neck, the recurrent nerve is then identified and isolated as far down in the neck as pos-

sible. The sternomastoid is retracted laterally, the vagus is identified, dissected as far as possible in the neck, severed and drawn under the common carotid and strap muscles. The recurrent is then severed. The vagus stump is usually long enough to suture to the recurrent stump without tension. We have used the finest arterial silk suture obtainable. Tantalum wire is not fine enough for this type of suture.

In two of the animals operated upon, plasma clot was used in addition to silk suture. In the dog, the vagus and sympathetic nerves are in a common trunk, the vagosympathetic trunk. Usually, however, it is fairly easy to distinguish between the vagus anteriorly and the sympathetic posteriorly, by dividing the trunk along a minute artery which runs along the side of the trunk. Usually, also, the vagus and sympathetic differ in color, the vagus being lighter than the sympathetic.

In 1924, Frazier and Chevalier Jackson anastomosed the descending hypoglossal to the recurrent apparently without success. Laslo and Fiertz, in 1945, describe a method of testing by faradic and galvanic stimulation of the larynx whether the paralysis of the vocal cord is permanent or not. This should be of value in determining whether surgery is indicated.

The protocols of four typical experiments follow:

Operation No. 1: Male dog, left vagus separated from sympathetic low in neck. Left recurrent nerve identified and severed. Vagus sutured to recurrent. This dog was observed by direct laryngoscopy for a period of four months after operation and there was no return of left vocal cord. We believe the failure here was due to using too large suture material and faulty technique.

Operation No. 2: Female dog, left vagus was identified, separated from sympathetic and severed low in neck. Left recurrent was identified and severed. Left vagus was sutured to left recurrent with fine silk suture. Plasma clot was then applied to suture line. Direct laryngoscopy five weeks after operation showed active movement of left vocal cord. Six months after operation, left vocal cord movements were about equal to right cord, and dog had a normal bark.

Six months after the operation the animal was killed and autopsied. A diagram of the neck is given in Fig. 2. It will be seen that there was a considerable neuroma formation around the point of suture. This apparently, however, had not interfered with the continuity of nerve fibres. At autopsy, the left vocal cord was slightly smaller than the right one.

All of the laryngeal muscles appeared to be equal in size on the two sides; in fact, the left cricothyroid muscle seemed to be larger, if anything, than the right one, which had not been denervated. The nerves and muscles, histologically, appeared normal except possibly for a slight increase in connective tissue.

Operation No. 3: Male dog, same operative procedure as No. 2. No plasma clot was used. Four weeks later, direct laryngoscopy showed active motion of the left vocal cord.

Operation No. 4: Male dog, same operative procedure as No. 3, with cutting of the left vagus and recurrent, and suturing with arterial silk suture. Five weeks later, direct laryngoscopy shows motion of the left vocal cord, but not as extensive as the right cord. The left cord appears smaller and paler than the right cord.

REFERENCES.

1. Gray, J. C. Boileau: A Method of Anatomy. The Williams and Wilkins Co., Baltimore, 1940.

2. Frazier, Charles H.: *Ann. Surg.*, 79:161, Feb., 1924.

3. Laslo-Fiertz: *Arch. Otolaryngol.*, Nov.-Dec., 1945.

J. BISHOP ANNOUNCES FIRST HYPONEEDLE WITH PLASTIC HUB.

The first postwar improvement in hypodermic needles, a needle with the first plastic hub, was announced by Paul C. Kerk, president of J. Bishop and Co., Platinum Works. The hub of the Albalon needle, as the company calls this innovation, is made of gleaming white plastic nylon. The needle itself is of stainless steel and is so beveled as to cleanly pierce and spread the epidermis without undue cutting, slicing or bruising the skin. This also provides a less painful injection.

The plastic hub withstands all commonly used methods of sterilizing, eliminates freezing of hub and syringe tip and thus tends to reduce breakage of syringe from this cause. Leakage around syringe tip is also minimized by the elastic qualities of the Albalon hub. The company has just released the Albalon needle for distribution through the usual trade channels, and will promote the sales of this and the Bishop production in the leading medical and hospital journals.

DIAGNOSIS AND EVALUATION OF FENESTRATION.*†

THEO. E. WALSH, M.D.,
and
S. RICHARD SILVERMAN, Ph.D. (by invitation),
St. Louis, Mo.

Until Julius Lempert in 1938[1] published his new technique for the fenestration of the labyrinth, otologists had nothing but sympathy to offer the patients in whom they diagnosed otosclerosis. In spite of the skepticism with which his first reports were received, Lempert's results and those of others who followed his technique have proved the value of the fenestration operation as the treatment of choice for clinical otosclerosis. The operation is here to stay.

The question now is not whether this operation is of value but in which case should it be successful and how can the results be evaluated objectively.

It is the purpose of this communication *1.* to describe our methods of examination of the hearing of those who consult us regarding the fenestration operation; *2.* to discuss critically existing methods for selecting patients for fenestration; *3.* to discuss the factors which, in the light of our experience so far, are of prognostic significance; and *4.* to suggest a method for selection of patients for operation and for evaluating results.

We do not propose to report the results of our series of 132 operations but to emphasize principles by citing pertinent cases.

EXAMINATION OF THE PATIENT:

When a patient consults us regarding hearing difficulty, a complete history is taken and a careful examination of the

*Read at the Seventy-eighth Annual Meeting of the American Otological Society, Inc., Chicago, Ill., May 31, 1946.
†From the Department of Otolaryngology, Washington University Medical School, Oscar Johnson Institute and Central Institute for the Deaf, St. Louis.

ear, nose and throat performed. Pure tone audiograms are routinely made for both air and bone conduction. We have been using a Maico D5 audiometer and the tests are performed in a room at McMillan Hospital with a residual noise level of 48 db. (*re:* 0.0002 dynes/cm.^{2}) as measured by a WE 330 sound level meter set at flat.

If it seems likely that the patient can be helped by fenestration he is given an appointment for further hearing studies at Central Institute for the Deaf.

It should be pointed out here that in St. Louis we have a somewhat unique situation because of the close cooperation between the Department of Otolaryngology at Washington University and Central Institute for the Deaf. These institutions are only two short blocks apart; it is convenient for the patient to walk directly from one to the other.

At Central Institute for the Deaf, the patient is tested under controlled conditions by individuals trained in the handling of the hard of hearing. The examination takes approximately six hours and is performed on two successive mornings from nine o'clock until noon. On the first morning a pure tone audiogram for both air and bone conduction is made, followed by certain speech tests on both ears and in the free field. On the second morning the pure tone audiogram is repeated and other speech tests are given. If the patient wears a hearing aid he is tested in the free field with the volume control of the aid set at maximum usable gain setting.

Detailed description of the apparatus is given below. The speech tests briefly are as follows: First the No. 9[2] test. This consists of groups of six spondaic words given to the patient through an earphone, beginning at an appropriate intensity so that he hears all six words, and then the groups are attenuated in four db steps. Threshold is the level at which he hears 3, or 50 per cent, of the words. The No. 12[2] test consists of four sentences at each level given as in the No. 9 test.

The P. B.[2] test is the most critical of our speech tests. This test was developed as were the others in the Psycho-Acoustic

Laboratory at Harvard University and is recognized as proportionately representative of the phonetic elements of normal spoken English. It consists of series of fifty words given at levels progressively attenuated in any desired step interval. Threshold is represented by the point at which the patient hears 50 per cent of the words.

When the examination at the Institute is concluded the patient returns to the hospital with his findings and the whole matter is discussed with him. He is told his chances for success or failure. He is informed of the unpleasantness of the procedure, of how long he will be in the hospital and of his postoperative course, and is then told to think the matter over and if he wishes the operation a date is set.

SELECTION OF PATIENTS:

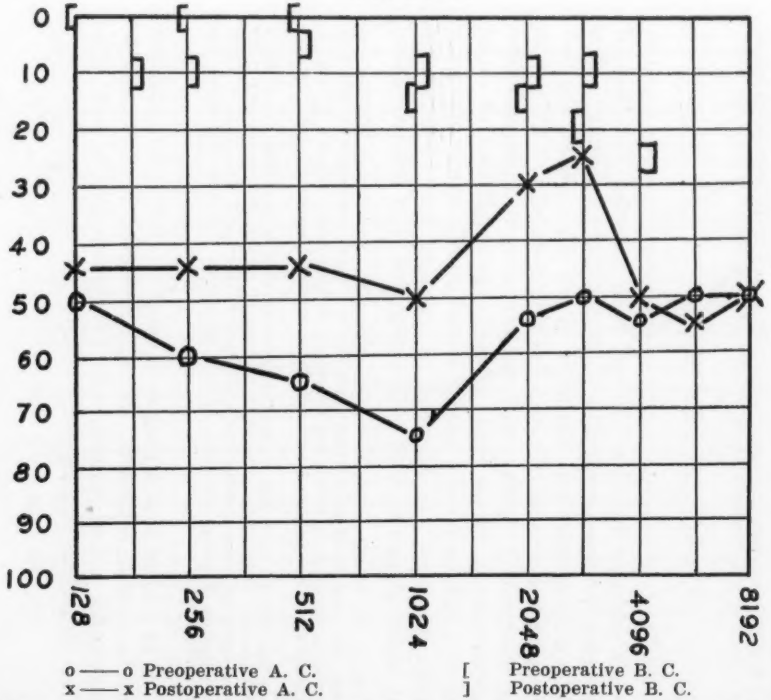
We agree that the classical criteria for cases suitable for fenestration are admirable. A patient *1.* who is young (between adolescence and forty-five years of age), *2.* who has a progressive loss of hearing, *3.* whose air conduction curve on audiometry is generally flat or rising in the high tones, and *4.* whose bone conductive loss is not more than 20 db. from 200 to 4000 cycles, presents an ideal case. We would, however, disagree with rigid adherence to these criteria.

AGE:

Age is important only insofar as the patient's response to trauma and his ability to heal are concerned. This is an elective operation and unnecessary risks should not be taken. A patient over sixty years heals more slowly as a rule than a younger person. Some of our most successful results have been in patients over fifty years of age. Figure 1 (Case No. 25) illustrates such a case. The patient, a man age 57 years, depends on his hearing for his living; he is an employee of the telephone company. At the other end of the scale it should be remembered that otosclerosis is a disease of youth and may be present even at birth. It is sometimes possible to diagnose clinical otosclerosis in young children. Our youngest case is that of a girl seven years old (see Fig. 2).

MR. H. M. CASE NO. 25. AGE 57. DATE OF OPERATION 6-12-45.

AUDIOGRAM
RIGHT EAR



o —— o Preoperative A. C.
x —— x Postoperative A. C.
[Preoperative B. C.
] Postoperative B. C.

RIGHT EAR (operated)

TEST	Date 6-1-45	Date 8-13-45
# 9 (18)	90	50
#12 (25)	92	54
PB (36 SRS 34 RH)	95	59
4C (22)	94	61
CD (15)	73	31

LEFT EAR

TEST	Date 6-1-45	Date 8-13-45
# 9 (18)	83	79
#12 (25)	86	88
PB (36 SRS 34 RH)	90	97

Fig. 1. Pre- and postoperative pure tone and speech thresholds in decibels (Case No. 25).

No. 9—Spondaic words. No. 12—Sentences. PB—Phonetically balanced words lists. 4C—WE 4C audiometer list. CD—Connected discourse—threshold of detectability.

Numbers in parentheses indicate thresholds for normal ears. Earlier date indicates preoperative thresholds; later dates are subsequent postoperative thresholds. Operated and unoperated ear data for speech are given. (SRS and RH are code symbols for different recordings of the same test.)

CASE REPORT:

A. F., (Case No. 22), female, age seven years, was first seen by us on March 1, 1945. Her mother stated that the child had had difficulty in hearing noticeable since she was three years of age. She had been examined by many otologists in St. Louis, most of whom had made audiometric examinations. The child was unusually intelligent and cooperative and the audiograms were reliable. Responses to successive audiometric examinations by different observers at varying intervals showed responses within 10 db at all frequencies. Examination of the ear, nose and throat was essentially negative. The tonsils and adenoids had been removed and the nasopharynx was free of lymphoid tissue. After considerable deliberation a fenestration was performed on the left ear on May 25, 1945. The Lempert nov-ovalis technique with mobile cartilaginous stopple was used. Fig. 2 shows the preoperative and postoperative audiograms of the left ear and the speech responses. This child was too young to respond to many of the words used in other tests, so that only a more simple test (No. 9) was used. Her mother states that since she has regained her hearing a great change has occurred in her personality. Before the operation she avoided playing with other children and would spend most of her time reading or playing alone. Since the operation she no longer sits quietly but is a normal, noisy, mischievous child.

BONE CONDUCTION TESTS:

The tests of bone conduction are designed primarily to determine cochlear function. It has been assumed that loss of hearing by bone conduction indicates cochlea damage. This is not necessarily so. Variables in the thickness of the cortex, the pneumatization and the thickness of the trabeculae in the mastoid together with the variation in thickness of the subcutaneous tissues must influence the conduction of sound to the cochlea from a source placed on the bone behind the ear. When we add variables in technique and of apparatus it is not surprising that bone conduction tests are unreliable.

Case No. 63 illustrates this point. The patient, a woman 39 years of age, had poor bone conduction (see Fig. 3). Rigid adherence to classical criteria would have precluded operation in this case; yet the patient is comfortably rehabilitated and has been returned to social adequacy.

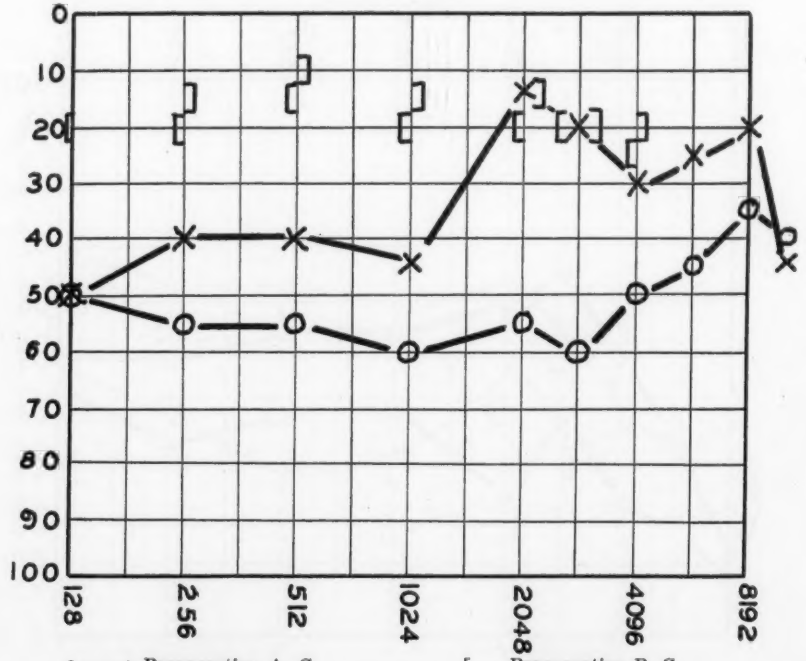
Case No. 47 (see Fig. 4) further illustrates the unreliability of bone conduction tests. The patient, a woman 50 years old, gave very poor responses to bone conduction audiometric tests and yet used a bone conduction hearing aid well. Since operation she has discarded her hearing aid.

It is evident that a prognosis based on the bone conduction curve woud be erroneous. We wish, however, to state emphatically that *not all* patients with a high tone loss by bone conduction should be considered suitable for fenestration.

A. F. CASE NO. 22. AGE 7. DATE OF OPERATION 5-25-45.

AUDIOGRAM

LEFT EAR



o —— o Preoperative A. C.
x —— x Postoperative A. C.
[Preoperative B. C.
] Postoperative B. C.

RIGHT EAR

TEST	Date 5-15-45	Date 7-23-45
# 9 (18)	72	73

LEFT EAR (operated)

TEST	Date 5-15-45	Date 7-23-45
# 9 (18)	80	55

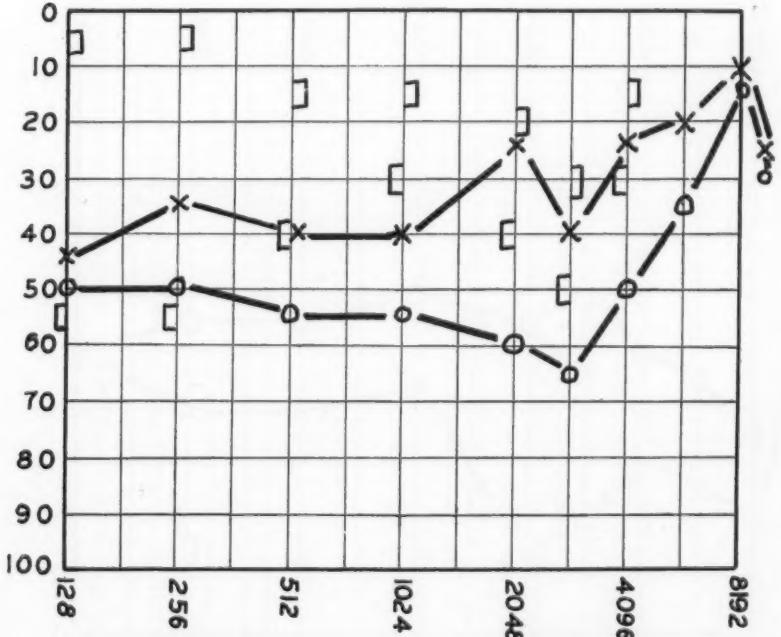
Fig. 2. Pre- and postoperative pure tone and speech thresholds in decibels (Case No. 22).

See Fig. 1 for explanation of symbols.

MRS. L. D. CASE NO. 63. AGE 39. DATE OF OPERATION 10-23-45.

AUDIOGRAM

LEFT EAR



RIGHT EAR

TEST	Date 8-24-45	Date 1-28-46
# 9 (18)	70	69
#12 (25)	78	71
PB (36 SRS 34 RH)	93	85-RH
4C (22)	79	75
CD (15)	66	63

LEFT EAR (operated)

TEST	Date 8-24-45	Date 1-28-46
# 9 (18)	79	53
#12 (25)	92	62
PB (36 SRS 34 RH)	107	66 R.H.
4C (22)	82	62
CD (15)	72	47

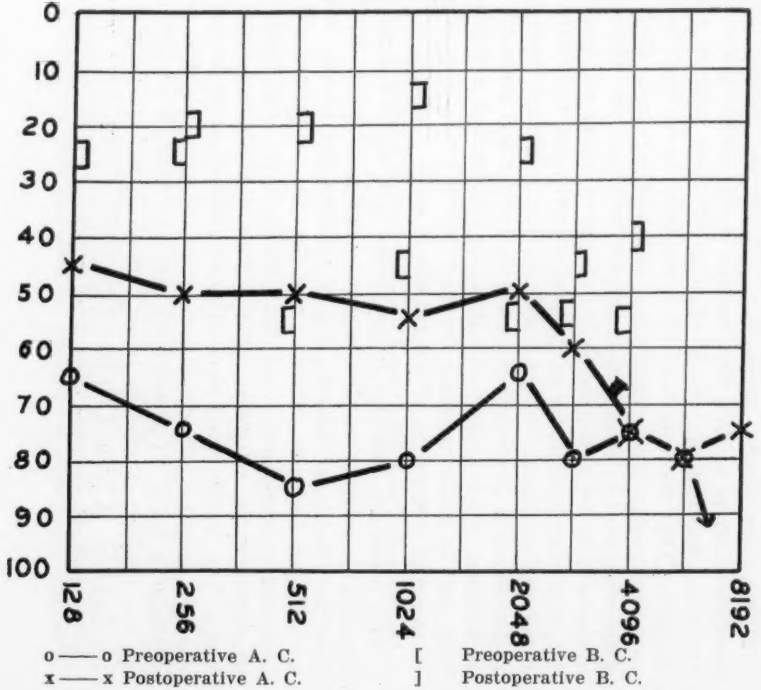
Fig. 3. Pre- and postoperative pure tone and speech thresholds in decibels (Case No. 63).

See Fig. 1 for explanation of symbols.

MRS. M. B. CASE NO. 47. AGE 50. DATE OF OPERATION 9-12-45.

AUDIOGRAM

RIGHT EAR



RIGHT EAR (operated)

Test	Date 8-3-45	Date 11-19-45
# 9 (18)	93	67
#12 (25)	98	72
PB (36 SRS 34 RH)	113	85 RH
4C (22)	98	78
CD (15)	86	61

LEFT EAR

Test	Date 8-3-45	Date 11-19-45
# 9 (18)	92	98
#12 (25)	94	96
PB (36 SRS 34 RH)	107	108 RH
4C (22)	101	101
CD (15)	83	84

Fig. 4. Pre- and postoperative pure tone and speech thresholds in decibels (Case No. 47).

See Fig. 1 for explanation of symbols.

Bone conduction tests in many cases are unreliable. We pay little attention to them except from the point of view of general screening of patients.

VOICE:

A last clinical criterion we should like to emphasize is the patient's voice. The otosclerotic talks in a "still, small voice." He modulates and articulates normally. The patient with any degree of nerve loss as a rule has a loud voice which is apt to be poorly modulated and he frequently slurs the consonants *s* and *th*, because he cannot hear himself say them.

LABORATORY METHOD FOR SELECTION OF CASES:

It has been clearly stated that although the fenestration operation is here to stay, the clinician is still confronted with the basic problem of proper selection of cases suitable for surgery. That there is need of a method which objectively evaluates postoperative results has also been stressed. Otologists who practice fenestration surgery or those who assume responsibility for referring their patients to others are familiar with the limitations of present practice as it involves these two problems. The purpose of the following portion of our paper is to present objective diagnostic and evaluative techniques which employ scientifically constructed articulation tests to assess cochlear function and to evaluate results in terms of restoration of the patient to social adequacy.

It is necessary, however, before either question is discussed specifically, to elaborate the concept of the articulation function mentioned previously. Fig. 5 contains the normal ear articulation function derived from the use of phonetically balanced monosyllabic word lists which have been treated statistically for reliability at the Psycho-Acoustic Laboratory.[2] The vertical axis shows the articulation score in percentage and the horizontal axis gives relative intensity in decibels. A list of 50 phonetically balanced words is presented to the subject at enough levels, 10 db apart, to complete the function. A patient is, therefore, credited with 2 per cent on the vertical axis for each word repeated correctly. Note

the heavy line in the graph at the 50 per cent mark. We repeat that this line represents the threshold of intelligibility which for this particular test is, by definition, the point at which the subject understands and can repeat half of the material presented to him. Note also the manner in which the articulation score climbs as a function of intensity — especially the steepness of the slope and the 30 to 40 db. range over which almost maximum articulation is achieved.

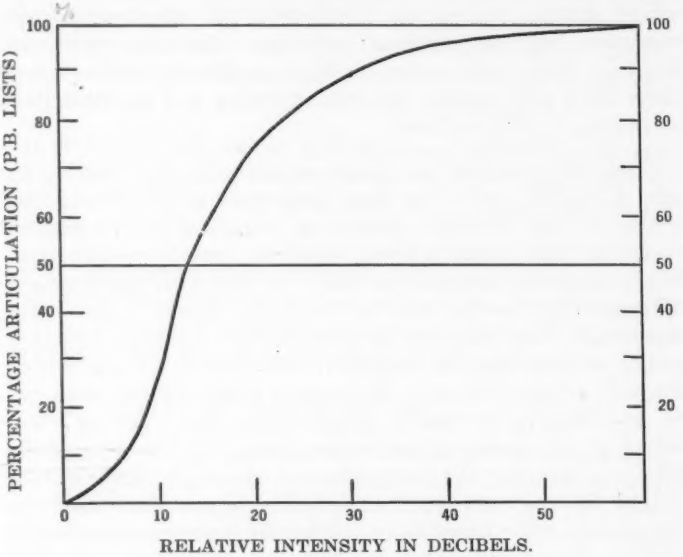


Fig. 5. Normal Articulation Function.

Since many equivalent lists are available, no lists are repeated, which eliminates any influence which might be exerted by familiarity with the test material.

Let us now turn to the use of the articulation test for the assessment of cochlear function which if present to any appreciable degree indicates, all other things being equal, that the patient is suitable for fenestration. It is a common observation among otologists that one group of hard-of-hear-

ing patients will hear proportionately better if the speaker's voice is raised; whereas another group will not do so beyond a certain point, regardless of the intensity of the voice. Individuals in the latter group often say, "Don't shout; I can hear better if you speak clearly rather than loudly." It is apparent, then, *that those patients who hear better when the voice is raised significantly have a conductive deafness which is overridden by the intense speech being carried to the functioning cochlea.* Such is not the case for the second group, where intense speech has relatively little effect on speech reception because cochlear pathology precludes improved hearing. This is the nerve deafened group. Of course, many individuals fall between the two extremes and are described as having mixed deafness.

These observations are given objective implementation in our diagnostic program. Our apparatus developed in the course of war research enables us to deliver to the patient speech at high intensity levels relatively free from distortion. If the patient's articulation score increases proportionately with intensity (as the score in the normal function previously described), then that patient has adequate cochlear function and is suitable for the operation. *In essence, an attempt is made to accomplish prior to surgery what surgery sets out to do — namely, to deliver sound to the inner ear by overriding or by-passing a conductive lesion.* If the attempt to deliver sound over the electroacoustic system is successful as judged by the maximum articulation score, then surgery, intended to alter beneficially the transmission mechanism of the ear, should accomplish the same result.

Note the articulation functions in Fig. 6 taken from our clinical records. Curve A is that of a patient who reaches a relatively high maximum articulation score if presented with speech at high intensity. This patient, therefore, has adequate cochlear function and would be a good candidate for surgery. Curve B represents a patient with mixed deafness, since his articulation score does not rise with intensity in the same manner as curve A. The conductive aspect of his deafness might be helped by fenestration but his prognosis would

be less favorable than that of the first patient. Note that in curve C increasing the intensity does not proportionately elevate the articulation score after a certain maximum has been reached. The curve of this patient shows that adequate cochlear function is not present and hence he should not be referred for fenestration. Surgery might deliver more sound to the inner ear, but lack of adequate cochlear function would preclude reception beneficial to the patient. It is interesting, too, that the thresholds of the three curves are practically identical, but the diagnosis and prognosis are based on auditory function above threshold; consequently, prime significance is attached to the *shape* of the articulation function and particularly to the *maximum articulation score.*

It should be pointed out that the suggested diagnostic procedure does not detect nerve deafness above approximately 3500 cps., but this area is of little practical significance for the purposes of the test.

The technique should commend itself to otologists because it is objective, quantitative and prognostic; furthermore, it eliminates the troublesome variables associated with tuning forks and with bone conduction audiometry.

LABORATORY METHODS OF EVALUATION:

Let us now consider objective evaluation of fenestration surgery. Orthodox techniques employe pre- and postoperative pure tone audiometry to evaluate results. In addition, some workers use various formulae to convert pure tone thresholds to thresholds for speech, while others depend upon the subjective judgment of the patient, which we feel should be done routinely but which is hardly scientific.

The use of pure tone audiometry (or any conversion formula which rests on it) as the sole criterion for evaluation is open to serious objection. In the first place, thresholds for pure tones are not always adequately indicative of auditory function above threshold. In other words, the threshold score does not always show how the ear functions over a wide dynamic range of speech intensities from soft to loud speech,

which is precisely what it must do in everyday oral communication. The divergence above threshold among curves A, B and C in Fig. 6 illustrates this point.

Secondly, postoperative pure tone audiometry neglects the change in the size and shape of the external transmission pathway which results from varying degrees of exenteration of bone cells. It should be recalled that audiometer receivers

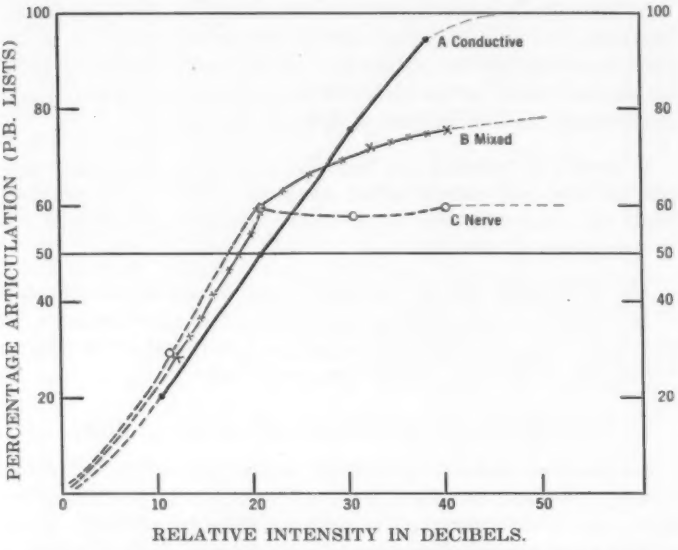


Fig. 6. Articulation for Conductive, Mixed and Nerve Type Deafness. (from Clinic Records)

are calibrated to work into a 6 cc. coupler and hence when the cubic content and the contour of the external cavity is altered, the preoperative yardstick is no longer valid. This fact may account for the discrepancy between postoperative pure tone audiometric results and observed social responses of many fenestrated patients as reported to us by such workers as Lempert, Meltzer, Day and Shambaugh. The precise

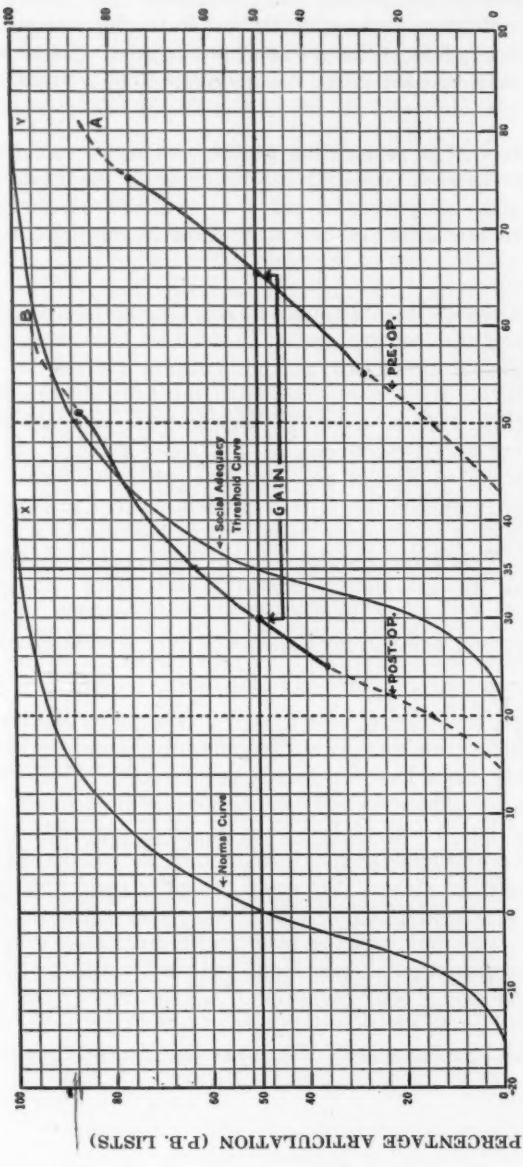


Fig. 7. Articulation Functions — Showing Area of Social Inadequacy.

acoustic laws which prevail for pure tones postoperatively should be determined experimentally. *It is clear, then, that in our present state of knowledge pure tone evaluative techniques or any method based on them must be viewed with caution.*

It is agreed that restoration of the patient to social adequacy in a dynamic acoustic environment is the basic aim of fenestration surgery. In order to evaluate our surgery according to this criterion, we again turn to the articulation function.

In Fig. 7 we see the articulation score plotted on the vertical axis and the loss for speech in decibels from a statistically established point for normal ears is plotted on the horizontal axis. As a curve moves to the left, it represents better hearing. Curves A and B represent the pre- and postoperative curves, respectively, of the same patient. If we focus attention on the 50 per cent line which indicates the threshold of intelligibility, it is clear this patient has gained 35 db and is still 30 db away from normal hearing as a result of surgery. This indicates the shift of audiometry threshold and is done for a wide variety of speech tests; however, although this datum constitutes valuable information, it does not fully describe the patient's adequacy over a wide range of intensities.

Note, then, the vertical line drawn at the point representing a 35 db loss for speech. It is generally accepted that if an individual has a loss for speech greater than 35 db he is a candidate for a hearing aid. He is socially inadequate. If, however, he has a loss of less than 35 db he can get by in most social situations and a hearing aid is not indicated. From the point of view of threshold of acuity for a speech, a 35 db loss is the dividing line between social adequacy and inadequacy. This point on the tests under discussion roughly represents conversational speech and ranges from 65 to 75 db. absolute level (*re:* 0.0002 dynes/cm.^{2}). Note further the vertical lines drawn 15 db on either side of the 35 db point — at 20 and 50 db loss for speech. The area bounded by these two

lines constitutes the area of social adequacy. In other words, the area supposes a hearing range of 30 db on the intensity scale, which is desirable for oral communication. It describes the patient's ability to hear soft, conversational and relatively loud speech (at 20, 35 and 50 db above normal threshold).

The individual will seldom be called upon to understand speech below the 20 db point because ambient noise would mask it. In addition, speakers seldom use the very loud speech above the 50 db point; and, if they must do so to achieve intelligibility the listener is not socially adequate. Incidentally, a dynamic range of 30 db is generally accepted for radio broadcasting as most desirable from the acoustic standpoint.

Let us now apply the concept of dynamic intensity range to the evaluation of fenestration surgery. Curve X represents the function of a normal ear. If we concede that it is important to hear soft, conversational and loud speech, then we can average the articulation score at the 20, 35 and 50 db points, which results in a score (or index) of slightly less than 100. If an individual has a curve similar to curve Y (the threshold curve for social adequacy) the index would be slightly less than 50. We suggest that any postoperative index of the order of 50 or better represents restoration of the patient to social adequacy. He would not need a hearing aid. The patient whose pre- and postoperative curves (A and B) are shown would have an index of 54 (12, 64 and 86 at 20, 35 and 50 db, respectively) and therefore has been socially rehabilitated.

It is clear, on the other hand, that if an individual has advanced from an index of zero to, say, 38 he has been helped to the point where he can hear loud speech, but he has not been completely rehabilitated. A small gain, however, from 40 to 50 would mean the difference between adequacy and inadequacy. *One must distinguish as the criterion for rehabilitation between the amount of gain and the point to which the individual's social adequacy index has been raised.*

The question might legitimately be raised that the thresh-

old score alone is sufficient to predict social adequacy. This would be true if no element of nerve deafness were present and the function would rise to maximum value. But since this is not always true, as has been explained previously, the average score is suggested. Just as we are accustomed to averaging hearing loss at critical frequencies, we must begin to think of averaging ability to hear at critical intensities, in this case determined by social criteria.

It is also conceivable that one might desire to attach more importance to certain points on the intensity scale in the same sense that one might attach more weight to 2000 cps. than to 500 cps. for speech intelligibility. In other words, ability to hear speech at a conversational level might be relatively more important than to hear 15 db above or below this level. This would probably be desirable and we hope soon to determine proper weighting on the intensity scale. Our purpose here has been to present the *concept* of determining social adequacy through proper use of articulation scores over a critical dynamic range.

The method appears to us to have value because it is objective, quantitative and reproducible. It can be so standardized that results can be presented and compared in a meaningful manner. It is obvious that the social adequacy index also has tangible social connotations in the same sense that the I. Q. has educational connotations. It should be made clear that we are not abandoning completely orthodox methods of diagnosis and evaluation, but we are supplementing these with more valid and objective procedures.

The clinician might object that the diagnostic and evaluative techniques presented in this paper are rather complicated and the equipment necessary to carry them out is elaborate and intricate. Neither objection is valid. Articulation tests and manuals for their efficient use should soon be universally available. Administration and scoring of tests are simple enough for the average technician. The equipment can be built at relatively low cost and consists merely of a high fidelity calibrated electroacoustic system; however, the equip-

ment must be carefully engineered and constructed, since accurate measurement is the key to successful implementation of the concepts here presented.

APPARATUS:

The apparatus was capable of reproducing known sound pressure levels under an earphone from 0 db. to approximately 145 db. r.m.s. (*re:* 0.0002 dynes/cm^2) at 1000 cps. For the field measurements an appropriately matched WE 753-B loud speaker was substituted for the earphone and was capable of delivering up to 115 db sound pressure level (*re:* 0.0002 dynes/cm.^{2}) at 1000 cps. six feet on the axis. Figure 8 is a block diagram of the complete testing system. The laboratory in which the equipment was housed consists of a large room containing a dead room and an adjacent control room. The dead room has an absorption coefficient of .83 as calculated by the Sabine formula. The ambient noise is 35 db sound pressure level as measured on the WE R-330 sound level meter with the selector set to flat. The meter had been checked for accuracy by the Bureau of Standards.

The patient was seated comfortably in a chair in the dead room and listened to the speech through a single PDR-10 earphone mounted on a double headband. A 6B cushion and dummy headphone (provided by Psycho-Acoustic Laboratory, Harvard University) covered the ear which was not being tested. The PDR-10 earphone is fed through an appropriately matched and calibrated 110 db Hewlett-Packard attenuator. Of course, the earphones were removed for field testing. A talkback microphone was suspended from the ceiling of the dead room. An instruction microphone was available to the operator for communication with the patient through the earphone or the loud speaker. This arrangement assured convenient and accurate rapport with the patient.

The remainder of the apparatus was mounted in a cabinet convenient to a window between the dead room and the control room. A resistance-tuned audio-oscillator was used as the source for calibration by pure tones. The source for the speech was originally the instruction microphone and then the electrical transcription reproducer. The recorded material was made according to the engineering standards set by the National Association of Broadcasters for transcription recordings and reproduction.[3] A detailed description of the individual components has been given by Silverman and Harrison.[4]

CALIBRATION:

The pressure response of the earphones was individually determined at the Electro-Acoustic Laboratory of Harvard University by methods now adopted as standard.[5]

The chart shown on page 555 indicates the sound pressure levels produced by the loud speaker at a distance of six feet on the axis in the dead room A fixed frequency of 1000 cps. was maintained. The electrical power fed to the speaker was measured with a standard vu meter bridged across the 500 ohm primary of the loud speaker matching transformer as shown in the diagram. The sound pressure level was measured with the WE R-330 sound level meter. This method of calibration has been adopted by the American Standards Association.[6]

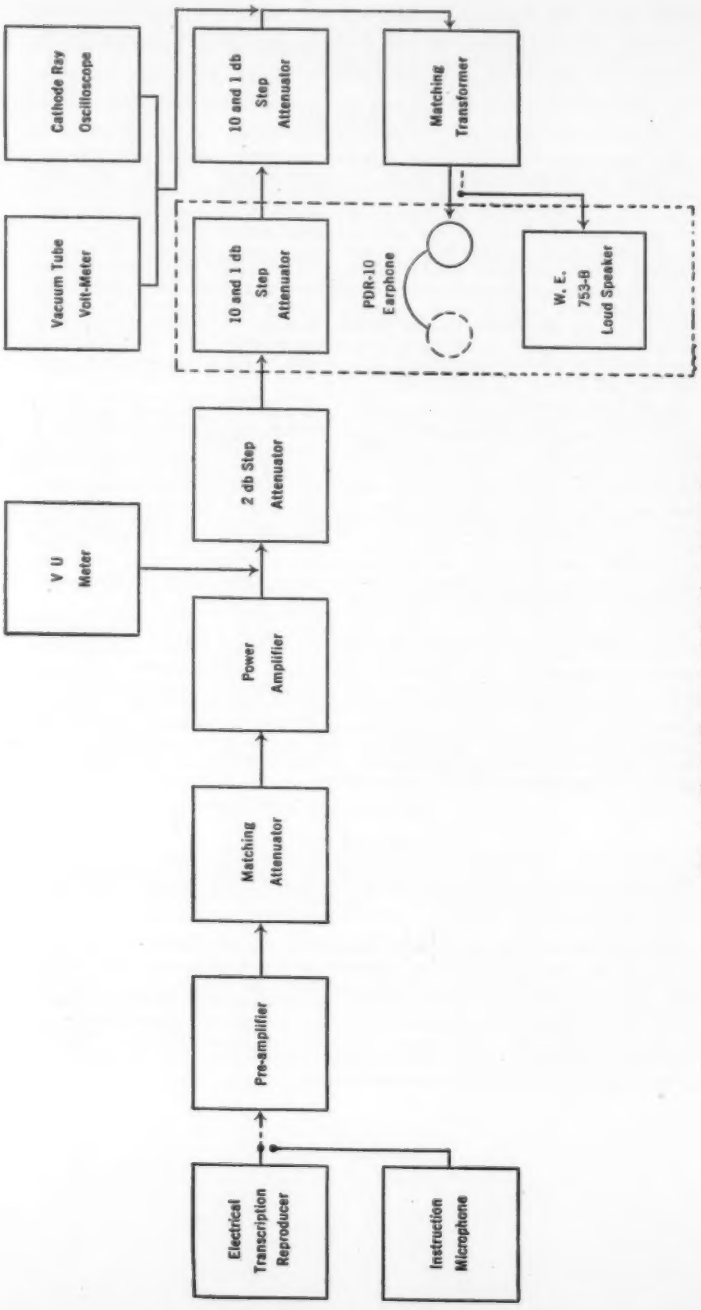


Fig. 8. Block Diagram of Testing Apparatus.

Watts Approx.	VU (dbm) O-VU = .001 watt into 500 ohm load	SPL (re: 0.0002 dynes/cm.^{2})
.000076	—11	60
.00023	— 6	65
.00076	— 1	70
.0237	+ 4	75
.00760	+ 9	80
.0380	+14	85
.0759	+19	90
.2372	+24	95
.759	+29	100
2.371	+34	105
7.590	+39	110
24 00	+44	115

Above 44 amplitude distortion begins to appear. Maximum speaker capacity 25 watts.

The speech level was determined by balancing for equal loudness with a 1000 cps. tone. The difference between the peaks of speech as measured by a vu meter and the 1000 cps. reference tone was 2 db. The 1000 cps. tone was then recorded on all articulation test records maintaining the 2 db differential. For live voice testing, the vu meter was used directly.

The Technical Committee on Transmitters and Antennas of the American Standards Association has pointed out, "The measurement of the complex and non-periodic waves encountered in electrical communication cannot be expressed in simple fashion in the ordinary electrical terms of current, voltage or power."[7] Hence, the principle of the vu has been applied in our tests.

The writers are indebted to Mr. C. E. Harrison for the description and design of the apparatus, and to Mr. Jules Detchemendy for its construction.

REFERENCES.

1. Lempert, Julius: Arch Otol., July, 1938.

2. O. S. R. D. Report No. 3802, Articulation Testing Methods—11, Nov. 1, 1944.

3. Technical Standards and Good Engineering Practices of the N A B for Electrical Transcriptions and Recordings for Radio Broadcasting, Dec. 1, 1944.

4. Silverman, S. R., and Harrison, C. E.: Electro-Acoustic Equipment for Clinical Auditory Tests, C. I. D. I. C-1, O. S. R. D., Feb. 15, 1945.

5. O. S. R. D. Report No. 3105: Response Characteristics of Interphone Equipment 1V, Jan. 1, 1944.

6. American Recommended Practice for Loud Speaker Testing, American Standards Association, C16.4—1942.

7. American Standards Association, American Recommended Practice for Volume Measurements of Electrical Speech and Program Waves, C16:5—1942.

THE USE OF GLYCERITE OF HYDROGEN PEROXIDE IN INFLAMMATORY AURAL CONDITIONS. CLINICAL REPORT.

ETHAN ALLAN BROWN, M.D., AND GEORGE KELEMEN, M.D.,
Boston, Mass.

Those topical applications which are used for the local treatment of inflammatory aural conditions must satisfy several requirements. Preparations containing benzocaine, procaine, chloral hydrate, antipyrin, camphor or menthol, alone or in combination, are useful for symptomatic treatment but have little or no germicidal action. The substances used which may be said to be germicidal are phenol, formaldehyde, iodine, the sulfonamides, urea and hydrogen peroxide. Each of these has virtues and limitations which warrant brief mention.

Although phenol has an antiseptic action in painful ear infections, its disadvantages have been listed[5] as extreme toxicity, high temperature and dilution coefficients and irritation by concentrations which are germicidal. McCulloch[5] says: "The use of glycerine to dilute phenol is irrational," and continues, "other mildly germicidal dressings should replace phenolized glycerine."

Formaldehyde, as formagel (a colloidal combination with gelatin), has been recommended as a 5-10-minute irrigation once daily. It has been shown[8] that for action upon some bacteria a 30-minute exposure to the 4 per cent solution is required. Unfortunately, sensitivity to both phenol and formaldehyde is common.

The limitations of iodine require no detailed description. Although it is bactericidal, relatively non-selective in action and effective in high dilution, it is toxic, irritating and allergenic, and should not be used for frequent applications for prolonged periods of time.

The sulfonamides are so specific in their action that the

Editor's Note: This ms. received in Laryngoscope Office and accepted for publication, March 10, 1946.

pure powders are not self-sterilizing. Although it has been reported by Tsuchiya, *et al.*,[10] that urea potentiates the action of sulfanilamide, and by Kopetsky[5] and Persky[9] that the action of sulfathiazole is increased by the presence of urea, nevertheless the sulfonamides are limited in action and associated with sensitizing potentialities. Loch, Main and Melon[6] have suggested that sulfanilamide acts to neutralize the enzyme catalase, allowing the formation of inhibitory concentrations of hydrogen peroxide to surround the cells. It would seem apparent that hydrogen peroxide in combination with urea, if available, could be used directly to achieve the same results.

The present paper describes a solution which achieves the objectives inferred above while being free of toxic, irritating and allergenic limitations. The solution consists of hydrogen peroxide (1.5 per cent) derived from urea peroxide (4 per cent) in substantially anhydrous glycerol containing 8-hydroxyquinoline (0.1 per cent) as a secondary stabilizing agent.* Four years of preliminary studies[2] has shown the solution to be stable. Laboratory studies have demonstrated its effectiveness against both Gram positive and Gram negative bacteria.[3] Patch test investigations have shown it to be free from irritating effects on the normal skin of 100 test subjects, and the infected skin and mucous membranes of more than 750 patients.[1] A preliminary report[4] has described its effectiveness in chronic suppurative aural conditions, 17 patients presenting dry ears within 14 days, and 12 patients within 38 days.

In contact with the water normally present in the tissues, the urea peroxide is decomposed into urea and hydrogen peroxide. The action of the catalase present, in turn, decomposes the hydrogen peroxide. In aqueous solutions, hydrogen peroxide is so quickly decomposed that it acts chiefly as a detergent and a deodorant. Although, in the ear, aqueous solutions cause maceration of the tissues, aqueous hydrogen peroxide is, nevertheless, prescribed by many physicians and used for self-medication by many patients. In anhydrous

*See advertisement, page 17 this issue.

glycerol, this action of hydrogen peroxide as derived from urea peroxide is prolonged, the solution becoming an effective bactericide.

The glycerol plays the usual part that it does in ear conditions. It has been widely accepted as a vehicle of choice in aural preparations. The remaining urea is, of course, a peptonizing agent. Its action in wound infection has recently been summed up in detail in these pages by Kopetsky,[5] and previously by Mertins.[7] Work in progress with the same dilution containing additional urea for a total content of 5.5 per cent will be reported upon in the near future.

The 8-hydroxyquinoline, itself an antiseptic substance, is present in a dilution of 1:1,000 as a stabilizing agent.

For the purposes of the present study, 29 consecutive patients attending the Ear, Nose and Throat Department of the Boston Dispensary and suffering from inflammatory aural conditions were chosen. Their ages ranged from 3 to 62 years. All were white; seven male and 22 female. The duration of their conditions was reported as from three days to 30 years. The bacteria identified from their lesions are listed in the first table and demonstrate a wide variety of organisms against which a solution suitable for treatment of ear infection must be effective.

The conditions were classified into the following groups:

Acute serous otitis media	4
Acute suppurative otitis media	4
Subacute suppurative otitis media	2
Chronic suppurative otitis media	13
Eczematous otitis externa	4
Furunculous otitis media	2

The exact previous treatment of these patients is unknown to us excepting in six individuals who collectively had been treated with any or all of the following: boric acid powder, boric acid-alcohol, sulfathiazole, methylene blue and mycozol.

The patients were given glycerite of hydrogen peroxide (4 per cent) and instructed to apply several drops to the external ear canal at intervals of four hours from arising to retiring. At each hospital visit the ear was washed with

glycerite of hydrogen peroxide, wiped dry and examined. Except as noted, no other medication was used.

Of the four patients with acute serous otitis media, one ear was dry in two days; one in one week; one in 28 days. For the fourth patient who reported improvement following six days of medication, we have no final report.

Of the three patients with acute suppurative otitis media, one presented a minimal discharge following three days, and the second after seven days of treatment. The third patient healed completely, presenting a dry ear in 14 days.

Of the two patients with subacute suppurative otitis media, the first showed no change in three days, and the second none in six weeks. The second patient was equally resistant to penicillin therapy.

The most encouraging results were achieved in the cases of chronic suppurative otitis media. Of the 13 patients, 10 presented complete cessation of the discharge, five within eight days, one in 14 days, one in 21 days, two in 27 days, and one in 44 days. The results are unknown in the other three patients who failed to return after three days of treatment.

Of four patients with eczematous external otitis, one remained unchanged, one was healed in seven days, and the other two were completely healed after 14 and 15 days, respectively.

Both patients with furunculosis of the external ear healed completely in five and 15 days, respectively.

TABLE 1. BACTERIOLOGY (18 PATIENTS).

Staphylococcus albus	9
Staphylococcus aureus	6
Streptococcus viridans	4
Streptococcus non-hemolytic	1
Streptococcus beta hemolytic	2
Colon group	2
Diphtheroid	7
Friedlander Type A	1
Gram negative bacilli	1
Gram negative diplococci	1
Pseudomonas aeruginosa	2
Monobacillary infections	6
Mixed infections	12

The present paper emphasizes the effect of glycerite of hydrogen peroxide upon chronic infectious aural conditions. Although the number of patients suffering from acute infections is comparatively small, it is to be expected that one of the qualities of glycerite of hydrogen peroxide, that is, its tendency to prevent desquamation, will be found of benefit in acute infections. Further studies concerned with its effect in such acute conditions will be the subject of a second report as soon as they can be completed.

In summary, the virtues and limitations of the common topical applications available for the treatment of inflammatory ear conditions are described. The composition and attributes of glycerite of hydrogen peroxide, a new solution containing urea peroxide (4 per cent) in hydrogen peroxide (1.5 per cent) as derived, are listed. The clinical results following the use of glycerite of hydrogen peroxide in 29 patients with inflammatory ear conditions showed 20 of 25 responding with complete remission or with improvement while still under observation. Four patients failed to return. No cases of irritation were observed.

REFERENCES.

1. Brown, E. A.: Studies on Tissue Tolerance to a New Glycerol Peroxide Antiseptic Solution. *Ann. Allergy*, 4:33, 1946.

2. Brown, E. A.; Abramson, H. A.; Gorin, M.; Kauffmann, H. O., and Shanley, E. C.: The Stability of Urea Peroxide in Glycerol, Ethylene Glycol and Propylene Glycol. (In press.)

3. Brown, E. A.; Krabek, Wilfred, and Skiffington, Rita: A New Antiseptic Solution for Topical Application. Comparative in Vitro Studies. *N. E. Med. Jour.*, 234:468, 1946.

4. Brown, E. A., and Owens, W. E.: The Treatment of Chronic Purulent Otitis Media with Urea Peroxide in Glycerol. *Arch. Otolaryngol.* (in press).

5. Kopetzky, S. J.: The Use of Otosmosan in Otology. The Laryngoscope, 55:5:216-227, 1945.

6. Loch, A.; Main, E. R., and Mellon, R. R.: Anticatalase and the Mechanism of Sulfanilamide Action. *Sci.*, 88:620, 1938.

7. Mertins, P. S.: The Use of Urea in the Treatment of Chronic Otitis Media. *Arch. Otolaryngol.*, 26:509, 1937.

8. McCulloch, E. C.: Disinfection and Sterilization. Lee and Febinger, Philadelphia, 1945.

9. Persky, A. H.: The Chronic Discharging Ear. An address read before Philadelphia Laryngological Society, Nov. 15, 1944.

10. Tsuchiya, H. M.; Tenenberg, D. J.; Strakosch, E. A., and Clark, W. G.: In Vitro Effect of Urea-Sulfathiazole Combinations on Sulfathiazole Resistant Staphylococci. *Proc. Soc. Exp. Biol. and Med.*, 51:245, 1942.

75 Bay Street Road.

414 Beacon Street.

Central Institute for the Deaf

NATIONAL RESIDENTIAL AND DAY SCHOOL FOR THE DEAF AND DEFECTIVES IN SPEECH

Approved by Advisory Council of Foremost Ear Specialists and Educators

New fire-proof buildings beautifully located opposite Forest Park. Modern Dormitories and Equipment. Best home environments. Pupils constantly in care of teachers or experienced supervisors.

ORAL SCHOOL FOR DEAF CHILDREN

C. I. D. offers all advantages of exclusively Speech Training and expert medical supervision for both Resident and Day Pupils.
Nursery School (2 years of age) through the Elementary Grades.

ACOUSTIC TRAINING FOR CHILDREN WITH RESIDUAL HEARING

Salvaging of Residual Hearing is a specialty of C. I. D. The Acoustic Method was created here. Group and individual hearing aids used for class instruction at all grade levels.

LIP-READING INSTRUCTION

Private and Class Instruction for Hard-of-Hearing Adults and Children.
Conversational Classes for advanced pupils. Speech conservation stressed.

CORRECTION OF SPEECH DEFECTS

Private and Class Instruction for children with normal hearing and delayed speech or defective speech.
Resident and Day Pupils (2 years of age through Elementary Grades).
Private Instruction for Adults.
Correction of Imperfect Phonation, Imperfect Articulation, Aphasia, Stuttering.

TEACHERS TRAINING COLLEGE

Two years of Training following a professional curriculum for applicants with adequate college qualifications. Graduates qualify for degrees of Bachelor of Science in Education or Master of Science in Education from Washington University. Graduates prepared to teach both the deaf and speech defective.

DR. MAX A. GOLDSTEIN, Founder · MISS JULIA M. CONNERY, Principal Emeritus

For further information address

DR. HELEN SCHICK LANE, Principal

818 S. KINGSHIGHWAY 10, ST. LOUIS, MO.

CONTENTS